DEBRIS FLOWS: Disasters, Risk, Forecast, Protection

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СЕЛЕВЫЕ ПОТОКИ: катастрофы, риск, прогноз, защита

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Ледники и сели на Кавказе

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Территорию Кавказско-Понтийского региона можно рассматривать как наиболее подверженный сходу селей и сложный регион мира. Селевые потоки могут быть охарактеризованы с точки зрения количества селевых бассейнов, величины различных характеристик селевых потоков, их мощности, объема отложений и сложности условий формирования, а также ущерба, причиненного жилым строениям и иным экономическим объектам. В этой статье рассматриваются все перечисленные выше характеристики селей.

сель, ледник, Кавказ

Glaciers and debris flows in the Caucasus

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The territory of the Caucasian-Pontides region can be regarded as perhaps the most debris flow prone and complex region of the world. Debris flows can be characterized, based on the amount of debris flow basins, frequency of different characteristics of debris flow flows, their power, volume of debris flow deposits and complex conditions of their formation, as well as per the damage inflicted to dwellings and economic objects. This chapter discusses these characteristics of debris flows.

debris flow, glacier, Caucasus

General characteristics

Debris flow phenomena are practically developed in all landscape geomorphologic areas, from low mountain relief to the alpine area. Considering that nearly 60% of the population lives in the valleys of small rivers, it may be concluded that more than one thousand inhabited points are located in the sphere of influence of these debris flow processes.

Statistical analysis shows that one of the major slope forming factors is intensive precipitation. The number of mud streams in different climatic areas varies from 65 to 85% of the total number of all debris flows. Debris flows connected with spring snow thawing do not exceed 3%, glacial debris flows form 12-13% of the total number of debris flows, and those occurring as a result of jams after debris flow shifts from 10 to 30%.

Principal present day exodynamic processes, that lead to the formation of reserves of loose material are formed, are: weathering, collapsed-talus phenomena, land sliding, snow avalanches, washing out of indigenous and water-accumulative deposits, and gully erosion.

Consequences of mud streams are defined by their density, which varies from 1100 to 2500 kg/m^3. Depending on the composition and density of debris flow mass, three types of debris flows are distinguished: stone aqueous, muddy, and muddy-stone. The important parameter of a debris flow is its nature and velocity of its motion. Very often the debris flow does not move unceasingly, but in separate ramparts. The average velocity of a debris flow is 10-15 km/h, but at the breakout of obstacles it goes up to 20-35 km/h and sharply increases in the volume.

Debris flow formation

On the territory of the Caucasian-Pontides region, based on the mechanism of debris flow generation, the nature of displacement of potential debris flow arrays and initial dynamics of debris flows, three types of debris flows are distinguished: erosive, landsliding, and glacial. According to E. Tsereteli [*2000*], the danger of debris flow formation is possible, when heavy rains falls with an intensity > 20 mm/day. Due to the fallout of 20-30 mm/day on high terraces and in piedmont, low mountain zones, so called “gully debris”, are formed. In the area of humid subtropics, at a gradient of 10-200, 200-300 thousand t/ha of mud, on average, is washed down the slopes. In Eastern Georgia at a rainfall intensity of 30-50 mm/day, favorable circumstances are created for the formation of mud streams with hard constituents. Such types of debris flows are characteristic of declivities bordering the cities of Tbilisi, Telavi, and Signaghi.

At the torrential precipitation of 50-80 mm/day, debris flows are formed in all channels with loose accumulations. When precipitation reaches up to 80-120 mm/day, independent of their geological construction, debris flows can be formed in all types of landscape-geomorphological areas.

One of the most disastrous events of the last century certainly was the Karmadon debris flow that occurred on September 20, 2002. The debris flow was of complex genesis in that the pulsation of glacier was superimposed on tectonic and volcanic phenomena. Based on its composition it was identified as a glacial debris flow. A huge amount of stone-glacial material from a height of about 4000 m above the mean sea level came down from the Maili glacier upon the Kolka glacier situated below, shifted it from its bed and the whole mass (about 130 million m^3) rushed downward, stopped only besides the so-called "Karmadoni Gate" ravine. The velocity of motion along the gorge reached 150-200 km/hour. As a result, the gorge, from its upper part (11 km), was filled with ice but 5 km below, by debris flow glacial stone mass. Several country cottages, restaurants, and bath complexes were destroyed, on a length of 3,5 km the motor road was completely demolished. The death toll reached 120 people, and about 100 people were unaccounted for.

A high activity of debris flow processes in the upper belt of mountainous regions is recorded practically everywhere. Unfortunately, debris flows are common phenomena in Georgia. For instance, the well-known Mleta mud flows have been known from olden times, but they entered into final catastrophic phase only after disintegration of the USSR. Mountain declivities at the headstream of the Aragvi River failed to feed enormous flocks of sheeps, which, in previous years, were driven in winter from mountains to Kizlyar steppe on the territory of Russian Federation. Closing of borders has brought about extreme over-grazing. Mountain meadows could not recover their turf-grassy layer that triggered extremely active erosion and as a result there began a destruction of the centuries old ecosystem. The whole livestock of sheep was practically lost and what is even more important there began irreversible processes of erosion. The Mleta village inhabitants are practically destined to migrate to safer places.

Debris flows are broadly developed on the entire south declivity of the Greater Caucasus, including Kakheti and Sheki-Zakatala regions of Azerbaijan. This region (over 1000 m high) presents itself an extensive debris flow basin. The Duruji River basin itself presents an enormous danger; in its middle course the town of Kvareli (Kakheti region, Georgia) is situated before the river discharges on to the plain. This inhabited locality was repeatedly destroyed by Duruji debris flows inflicting enormous losses accompanied by loss of life. Here the total volume of potential debris flow forming masses were 500 million m^3, but in specifically dangerous hearths more than 150 million m^3. From 1888 to 2000, 25 large and 5 disastrous (in 1949, 1963 and 1975) debris flows occurred. More than 200 people lost their lives, and enormous damage was inflicted to the Kvareli region and the town of Kvareli.

Records of debris flows

For the last 100 years more than 200 destructive debris flows have been registered in Azerbaijan, and these have inflicted U.S. $1,5 billion damage to the economy of the country. More than 100 inhabited localities, with a population of about 700 thousand people, are constantly threatened by debris flows. Out of 3 thousand motor roads of the country, about 1,2 thousand roads pass through high risk debris flow areas, are constantly subjected to destruction. In July 2004, in the Shekin region, the areas between debris fan and debris flow source areas with an extent of 10-15 km which are transit parts of the rivers, debris flows washed out motor roads and part of the railroad track Baku-Balaksen. In the same way debris flows destroyed supports of power transmitting lines and communications.

Destruction by debris flows

Unlike usual freshets, debris flows possess an enormous destructive power, arising from their hydrodynamic peculiarities. Moving like waves, they fell hydrotechnical erections, destroy bridges and roads, and inhabited localities; inflict large economic damages; and are quite often accompanied by human victims.

Modern and ancient glaciation

The main hotbed of glaciation in the catchment of Terek River is a Kazbegi-Djimara array (Hoh Ridge). The average height of the array is 4500 m. On the walls of this array begin powerful hanging-valley glaciers – Devdoraki, Ortsveri (Gergeti), Suatisi and others. Pockets of glaciation are confined to the top of the main range, more 3800m. (Zilga-hoh, Kalasani and Chaoukhi) and the Divide Ridge on basin of Kistinka river. The basin of the Terek River accounts for 12,6% and 12,1% of all recorded glaciers of Georgia. According to K.I. Podozersky [*Podozersky, 1911*], there were 63 glaciers with an area of 89,19 km^2. According to studies by R.G. Gobejishvili [*1989*], now in the Terek 99 glaciers with an area of 67,19 km^2 (Table 1).

In the basin of the Terek river, the greatest distribution has cirque glaciers, they accounted for 53,5%. Next come the hanging glaciers-33,3% and slope glaciers (7,1%).

On the square are the glaciers of slope-valley type (48,2%). Almost the same area occupied by hanging (17,9%) and cirque (17,1%) glaciers.

In the basin of the Terek river, meet the glaciers of varying exposure. Glaciers with Northern exposure points accounted for 21.4%, and glaciers of the southern points -12,2% of all the glaciers in the basin. On the leading position of the square is occupied by glaciers with expositions of the southern points (55,8%).

Table 1. Distribution of glaciers in the basin of the Terek River [*Gobejishvili, 1989*]

Name of river basin	**Number of glaciers**	**Area, km^2**
Amali	6	11,74
Khretis-khevi	1	0,04
Chkheri	7	9,86
Kesia	3	1,10
Mnaisi	7	9,55
Suatisi	9	17,32
Dzhimara-don	3	0,34
Tepi-don	10	2,52
Resi-don	6	1,29
Siveraut	5	0,70

Name of river basin	Number of glaciers	Area, km^2
Source of Terek	6	2,61
Tsotsola-don	2	1,28
Desidon	7	1,50
Djouta	6	1,81
Kistinka	21	5,53
Total	99	67,19

In the Terek River basin common to the small size of the glaciers, the area of which does not exceed 0,5 km. In number, accounting for 71.8 per cent and 8.0 per cent only major recorded glaciers. On the square leading place is occupied by large glaciers, they accounted for 58.5% of total glaciation in the basin of the Terek river. Basin of Amali River is located on the Northeast slope of Mount Djimara in Kazbegi array. It is the first right tributary of Terek r., where there are glaciers. In region are seven glaciers with an area of 11.71 km^2. Morphologically they are related to the glaciers of different types and have different dimensions. The largest is the slope-valley Devdoraki Glacier, area of 7,55 km^2. It starts at the top of Mt. Kazbegi, and reaches in length 7,0 km.

Devdoraki, widely known for its glacial collapses that were noted in 1776, 1778, 1785, 1808 н 1817 years. A powerful landslide occurred in the year 1832. As a result, in the valley of the Terek River, the dam height was shredding inserts, 100 m and a length of about 2 km. Terek River was stopped during 8 hours [*Statkowsky, 1879*].

The most active glaciers in the Caucasus over the past 100 years - Devdoraki, Abano. The first of them for 1881-1970 years, retreated 16 m, and the last (Abano) for 1882-1970 years even stepped on 79 m.

Karmadon catastrophe

It should be noted that sometimes-catastrophic events are generated in one place, and the result of their destruction is worst for many miles from home. The tragic event occurred on September 20, 2002, when the catastrophic collapse of the Kolka glacier, located in combed the area of the Greater Caucasus mountain range, on the border between Georgia and Russia has led to the formation of a powerful glacial-stone debris flow, through the narrow V-shaped valley of Genaldon river, destroying standing in a low-lying part of the structure of Karmadon village and claimed the lives of more than 130 people. The reason for this was a whole group of factors. The impetus was the pronounced thermal anomaly within the northern end of the Kazbegi volcanic centre [*Bogatikov, Gurbanov, 2003*], and an unusually rainy summer of 2002, when the glacier basin has accumulated a critical mass of water [*Kotlyakov et al., 2014; Bondyrev, Zaalishvili, 2005]*, etc. However, there is still a lot of unknown. For example, whether this event is purely local in nature, or whether it has a broader scope, covering and surrounding area? Whether it is a consequence of the above-mentioned reasons only or it is based on a whole range of processes and phenomena, including seismic and tectonic nature?

Many other glaciers, although less active and had retreated to a few hundred meters, also actively behave and over the past 100 years-80 attacked several times, leaving the clear traces in the relief of valleys-the whole series of moraine. Another, for example, by Gobejishvili R.G [*1989*], on the south slope of the Great Caucasus below the ends of the tongues of glaciers (1970-1975 years) there were 5-7 course-moraine shafts formed in 1890-1975, then there are glaciers every 15-20 years. Amid the retreat of glaciers in some periods they are opposite, attacked, t. e. happened oscillation their terminal stations. V.M. Kotlyakov [*1968*] distinguishes four kinds of fluctuations of glaciers: 1) forced oscillations due to changes of the external load, on speed accumulation or ablation of ice; 2) high frequency oscillation of sliding velocity, caused by changes in roughness lodge glacier under the influence of melting ice and sub-glacial runoff; 3) low-frequency fluctuations associated with penetration of temperature fluctuations in the thickness of the glacier; 4) relaxation self-exciting oscillation, arising from no-stationary of nonlinear kinematic relations in Glacier; they are expressed in the sudden developments glaciers». Of these, the first and fourth species are fundamental, in connection with which the glaciers are divided into normal (the first kind of hesitation) and pulsating (the fourth kind).

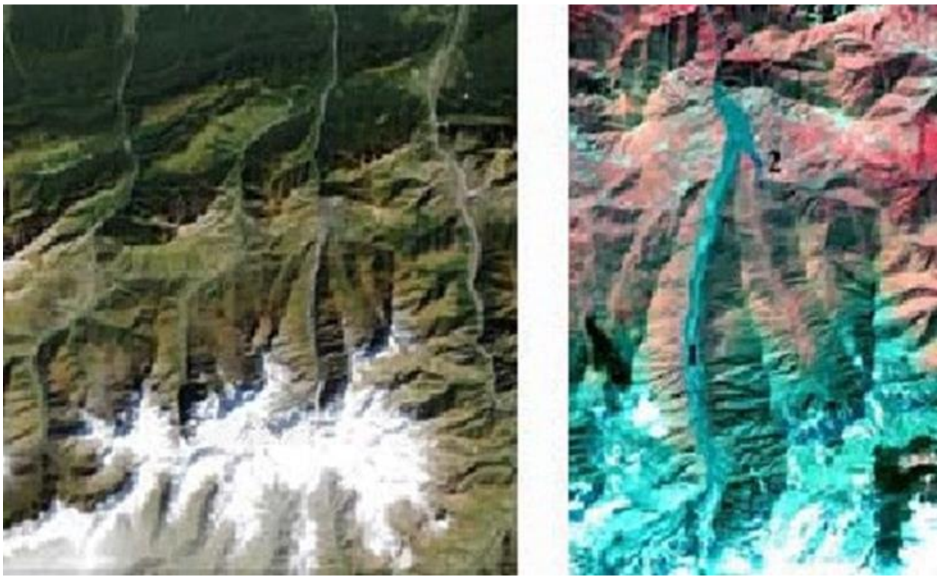

Fig. 1. Satellite's images of North slope the Great Caucasus on different scale in part of Kolka glacier advance, caused the derailment has debris flow (1) and education boost Lake

The main part of the glaciers of the Caucasus consists of a "normal" glaciers. Surging glaciers in the Caucasus for a bit. Glaciers of conical peaks and the hanging Valley celebrated only in the Greater Caucasus, on its northern slope, with the first of them are confined to two volcanic arrays of Elbrus and Kazbek. The average value of the retreat of the glaciers of conical peaks for 1881/1887-1965/1970 years. is 810 m, and the hanging valley-670 m.

Fluctuations of glaciers of conical peaks vary in a very wide range, much larger than that of glaciers other morphological types. This is due to their specific terms of location on the high volcanic peaks, open the carrying moisture atmospheric flows, particularly wind regime in the areas of nutrition, the difference in altitudes and expositions end languages glaciers. The largest of these glaciers retreat values exceed 1000 m (Table 2).

Table 2. The retreat of glaciers and conical peaks (Kazbegi) for the 1881/1887 - 1966/1970 [*Gobejishvili, 1989*]

The name of glacier	**Period**	**Number of years**	**The magnitude of the retreat, (m)**	
			Geral	**In yerat**
Abano	1882—1970	88	+78*	+0,9
Devdoraki	1881—1970	89	16	0.2
Gergeti	1882—1970	88	936	10.6

*+ sign indicates the strike of the glacier

The minimum value of the retreat from Devdoraki glacier -16 m, and glacier Abano (m. Kazbek) for 1882-1970 years even stepped on a 78 m. All this suggests that the glaciers of this type are the most different surface mode, with some of them balance mass is very close to zero over the past 40 years - 20 (Devdoraki) or even a positive (Abano).

This is mainly due to the size and height of power regions languages end glaciers. For example, all the glaciers, which have value less than 600 m retreat, with altitudes more than 2750 m, and the ice factor they have over 2.5. The exceptions are the glaciers Devdoraki and

Abano. The first of them height end language equal to 2260 m, but the ice factor is 6.0. At glacier Abano, on the contrary, when a small glacial ratio (1.2) very high ends the end of language and while 75 percent of the ablation area closed with a solid cover moraines, which drastically reduces the amount of melting and so the whole glacier in recent decades have noted the positive balance [*Gobejishvili, 1989*].

For the period from 1882 to 1969 timeframe fixed the following values retreat hanging valley glaciers: Mna –1022 m (ou 11,9 m/year), Suatisi Earth – 500m (on 5,8m/year), Suatisi average –277 m (on 3,2 m/year) and Suatisi West – 1230 m (14,3m/year). For 1965/1969 years, due to the significant reduction of ablation areas they have as a result of the retreat, the ice factor in all glaciers has declined dramatically, particularly much at glaciers Mna (6,66) and Suatisi (3,17). The greatest retreat (979-1230 m) highlights at glaciers located on Mount Kazbegi, had taken in 1882 years, relatively gentle languages South-Eastern and South-Western exposures. Small retreat (277-410 m) associated either with good nutrition glacier (Sofrudzhu), or with closed the end of powerful language superficially moraine cover (Middle Suatisi) [*Gobejishvili, 1989*].

Morphological traces of Quaternary glaciations in the Kazbegi array distributed widely, but they are presented here are a few typical forms.

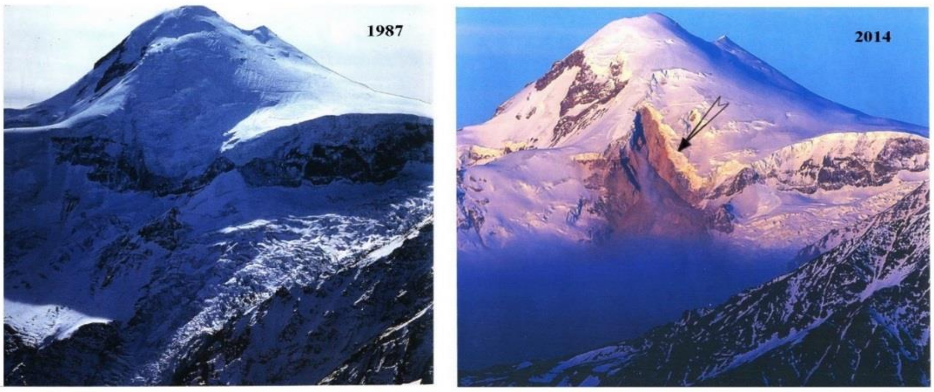

Fig. 2. Devdoraki glacier collapse (2014) and its consequences in Terek river valley.

Movement disastrous and other phenomena

Kazbegi glaciers Djimara's array (Devdoraki and Kolka), identified a number of manifestations of processes of a catastrophic nature. In order to study spatial changes Devdoraki glacier, 1974-1990. G.S. Abuladze [*Abuladze, 1999*] was 20-times repeated large-scale photo-theodolite survey (scale 1:2500). Found that the Devdoraki glacier has experienced the most intense changes during 1974-1977: for 3 years, he stepped on 15 m.

According to the same author [*Abuladze, 1999*], perimeter Djimara's ring structure (fig. 4б) clearly controlled geometric form located within the glaciers and the overall pattern of their radial placement. A large part of the array (in upper r. Terek) is occupied by the modern glacier. Kolka glacier catchment with topographical accuracy is embedded in a zone passing here fault sub-latitude aa1-bb1, which width reaches approximately 3 km. It is bounded by three separate faults; box form of depth throughout the basin is, on average, 700 m. The lower boundary of the zone within the lineament KK1 good coincides with roots hanging glaciers good coincides with roots hanging glaciers, located on the starboard side of the glacier Kolka. Inside the ring structure, in the zone of the fault passes sub-latitudinal another diagonal structure MOP clearly controlled the line of the left side of the glacier Kolka.

The most prominent and reliable source of information on the nature of the surface changes Devdoraki glacier and their intensity is map elevation changes and the nature of the surface of the glacier, which shows the total lifting-lowering of the surface. Found that the surface of the glacier has increased over a specified period to 12 m., and its lateral experienced local decrease (-12). Glaciological and cartometric analysis showed that during the period 1974-

1977, in increasing heights Devdoraki surface of the glacier is glacier not dominated by climatic conditions and internal processes in the body of the.

With a view to predicting changes in elevation of the Devdoraki glacier, has developed a new method for determining the surface ice speeds to determine the speed of the escaping ice cusps towards the end of the language. So, the most remote glacial Hill reaches the end of the language through 31 year (i.e. 2008), and the closest-through 5 years.

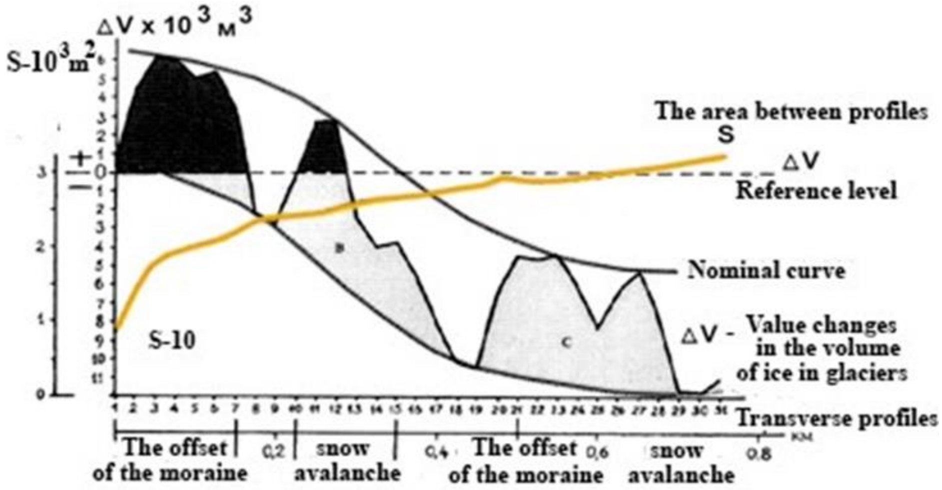

Fig. 3. Distribution of values of ice volume changes the final part of the glacier is equal Devdoraki hypsometric belts (every 25 m). Determined based on materials re terrestrial stereophotogrammetrical shooting 1974-1977.

On a space image obtained in 1988, well visible stain dark tones, striking against the backdrop of freshly fallen snow. This spot corresponds to the footsteps of melting snow on the surface of the glacier (photo, ring I). Application of the method of indication analysis suggested the presence of thermal anomalies here. In the picture you can see that the configuration of traces of snow melting on the surface of the glacier is the plot of the big ring structure array Djimara (see fig. 4) where it is at the confluence of the glaciers Kolka and Miley, crosses the area of linear structures.

In proof of this, the results of works of various authors, conducted independent research here. Remarkable work on the definition of the electrical conductivity of ice and melt water of the glacier [*Fleetwood, 1973*] who showed. That the highest heat conductivity coincides exactly with this part of the surface of the glacier. This position was further enhanced by the fact. That natural snow and ice melting on this site, great impact thermal erosion impact of sub-glacial water-features of the spatial properties of temperature coefficients in the zone of ablation.

According to the analysis of spatial information, the Midagrabin glacier, during this period, recorded the vanishing traces of snow avalanches (fig. 4, ring II), as evidenced by: the nature of photo-ton of these deposits, trajectory and dynamic peculiarities of their passage on the glacier. Place of origin (hearth) avalanche on the left side of the glacier good matches node crossing a small ring structure and the lineaments (Fig. 4, a).

It is assumed. the process of development of such forms within two ring structures identified in the Djimara's array ("physiographic" and "infra-physiographic"), associated with thermal anomalies in the area.

Instrumental-sensitive observations conducted at the Mleta, solifluction processes often destroy vegetation continuity, creating numerous horizontal micro bend slope and scar the landscape of the cryogenic "scars" test site (the basin of the r.Aragvi), Depending on the slope the slope and degree of coverage, speed sod offset is measured in a wide range (of 15 mm on 150 mm in years), and in some places solifluction processes are catastrophic, baring the bedrock on their way. Solifluction processes often destroy continuity of vegetation, creating numerous horizontal micro-dog leg slope and scar the landscape of the cryogenic "scars" [*Tsereteli et al., 2000*].

Our studies in the summer and autumn of 2003, intended to highlight features of the development processes of modern tectonics, namely exogenous Geodynamics (landslides, debris flows, deep and lateral erosion, etc.) in the valleys of the tributary Terek River (interflovial r.r. Genaldon-Gizel′don), which allowed, in general terms, describe the following picture.

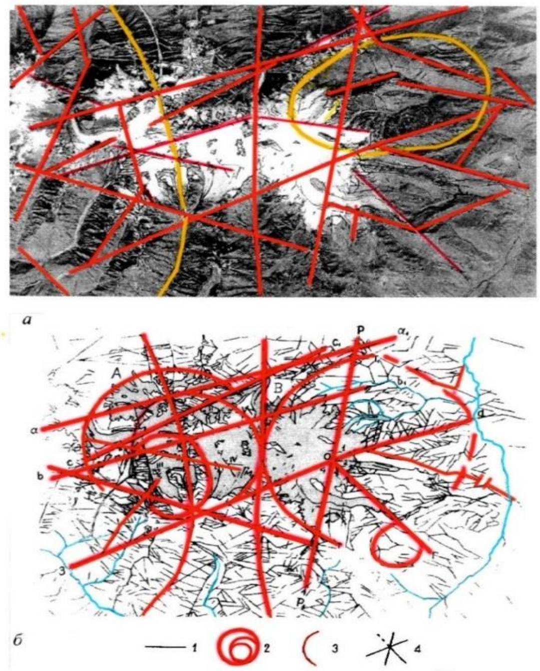

Fig. 4. Satellite photograph Kazbegi-Djimara’s array (s) and expressed in the relief of tectonic structure (b). 1 - (aa1 - bb1) - border break on sub latitudinal which exactly superimposed Kolka ice basin, 2 – Ring structure Djimara (a) and her Ring structures small diameters, 3 - Arch structure Kazbegi array (b), 4 - fragments of a hexagonal structure (OP, Od, OГ, OP1, 03) submitted by equal (1, 2, 3, 4) horizontal angles [*Bondyrev, 2003*].

The region is located in the zone of debris-flow hazard and risk, threatening the destruction of settlements, buildings and structures, and mortal danger to residents. Research conducted with the 80-ies of the last century, it was found that in virtually all river basins are large numbers of fragmented rock denudation processes. Today, however, it should be borne in mind that as a result of the Spitak (1988), Racha (1991), Barisakho (1992), and other earthquakes greatly complicated geodynamic state of the slopes of the Central Caucasus and neighboring areas, the folded soft rocks (sandstones, shale’s, etc.). As a result, in the areas of formation of debris flows have accumulated huge amount of solid material gravitation demolition. In addition, combed the area of the Central Caucasus major suppliers of solid materials are fresh moraine sediments represent an almost inexhaustible source of potential debris flow mass.

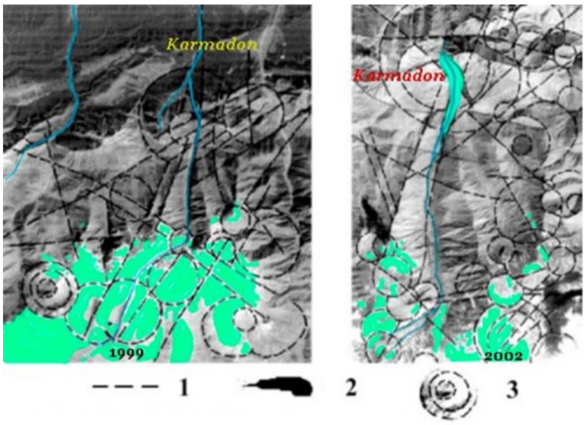

Fig. 5. Linear and non-linear structure of the Karmadon Gorge. 1 – line of disjunction violations, 2 – route fluvial-glacial and alluvial fan of debris with backwater lakes Saniba, 3 – ring structures

Requirements: in rivers flat, at the mouths of tributaries of debris flow nature (including Dargavs River). All of this requires a major review of the situation and, in case of impossibility of evacuation of such objects, the mandatory establishment of permanent service to the aerospace field and at best integrated monitoring volcanic, seismic and glaciological hazards. Introduction of materials for Aerospace Survey and analysis of modern computer technology has radically to revise a number of traditional terms and to re-evaluate the mechanisms of a number of modern processes.

To date, the population living in that area, it would be protected from catastrophic debris flows, as that old buildings and structures were built on high ground above the water and debris flows of the processes and artificial protective structures. However, in recent decades, residential and administrative buildings have been developed areas that do not meet safety requirements: in rivers flat, at the mouths of tributaries of debris flow nature (including r. Dargavs). All of this requires a major review of the situation and, in case of impossibility of evacuation of such objects, the mandatory establishment of permanent service to the aerospace field and at best integrated monitoring volcanic, seismic and glaciological hazards. Introduction of materials for Aerospace Survey and analysis of modern computer technology has radically to revise a number of traditional terms and to re-evaluate the mechanisms of a number of modern exodynamic processes.

Qualitatively new objects of the natural environment, directly related to the geological and geomorphological sites and play an important role in shaping and modifying their physic-mechanical parameters is nonlinear (circular, oval, swirl, etc.) structure. It is believed that the circular structure and non-linear morphological is one and the same. However, non-linear morphological represent only a small, most clearly expressed in the relief and geological structure of the isometric in terms of natural phenomena, the genesis of which are based on the processes associated with the development of modular, nuclear, arched, volcanic, etc. Nonlinear structures resulting from specific forms of differentiation of matter and energy in the lithosphere. The new areas of concentration are interpreted nonlinear nature and imposed on them disjunctive systems of neotectonic and modern stages-as hotbeds of active development of dangerous geodynamic processes.

This is because the dynamic stresses in the Earth's crust, these sites affect changes reducing their physical-mechanical and chemical parameters (strength, resistance to weathering, etc.) than they are qualitatively different from those of a stable site. Rocks here have less elasticity, and therefore a lower resistance to kinking. Anyone, even a slight change of geodynamic regime in these nodes instantly evident in the dramatic increase of the whole range of natural-catastrophic exogenous processes (landslides, debris flows, rock avalanches and landslides, rock-falls, etc.). As you can see from Figure 2, land intensification of geodynamic processes is well correlated with ring structures identified by photo-interpretation of space images.

Right-bank tributaries Karmadon (the left tributary of the Genaldon river), then to r. Lako-don and further East along the slope to the road Dargavs-Tmenikau.

It should be noted that among other causes which determine the development of local Fort terrain and landscapes, a role-play and active thermal processes of earth-crust. Not only locals but also tourists use the fall-celeb properties of the thermal springs.

By area from Tmenikau to the valley of the Belaya River in the upper reaches of the river Genaldon was. No more than 10 small (up to 80-100 m^2) and 3 large (over 800 m^2) debris flow-transformed into vast debris fan, 10 small new and 2 large-up to 130-200 m multistage landslide bodies.

Fig. 6. Shedding cones to starboard Genaldon river in the transit zone has lodging

On this site registered development: collapse-active landslides in all left tributaries (over 18); powerful cones of debris material on the right side, the top of which, for the most part, have the kind of landslide bowls. The body of the cones of incised erosion to a depth of 2-3 m (middle), and in the upper reaches are more widespread on both sides (without the formation of sod-soil layer).

It is noteworthy that all the newly identified bodies of landslide and debris fires are confined to the parts of the development interceding argillites thick, sandstone and siltstone, Ksurtsk' Zinuarsk, Mziur suit (rarely to the retinue of v. Bejno) and are confined to the lines of the previous disjunction dislocation or are their markers (see diagram). This allows the entire network reinvigorated the disjunctive tectonic activity in the area, with the exception of Katadon Gorge.

However, it should be noted that this catastrophe only was one of those that were recorded at the same time (at intervals of 4-9 days) almost the entire mountain and highland areas of the Caucasus.

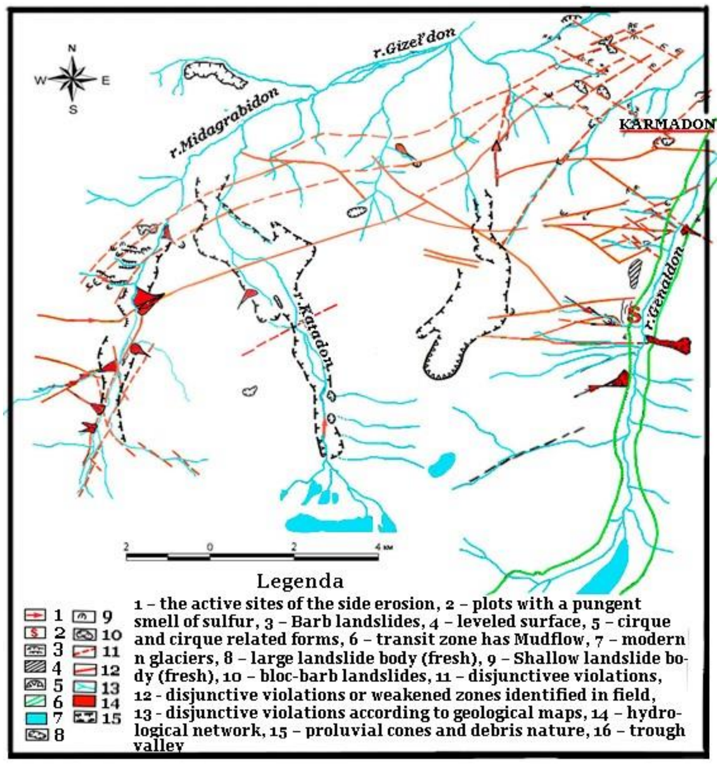

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Fig. 7. Map of intensifying current processes on a stretch of the northern slopes of the Kazbegi (according to fieldwork in August-September 2003, conducted by Igor Bondyrev)

Thus, once again demonstrates that all these catastrophic events are not single manifestations of natural events, and represent the overall picture of the changing nature of our planet, which in no small part to blame the man himself.

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