НАШИ ГОСТИ

УДК 551.33

GLACIAL AND PERIGLACIAL PROCESSES OF GEORGIA

 I. V. Bondyrev

Ivane Javakhishvili Tbilisi State University, Vakhushti Bagrationi Institute of Geography, 1, Chavchavdze Ave., 0179, Tbilisi, Georgia, e-mail: example@tsu.ge

There are about 786 glaciers registered in the mountains of Georgia. The possible consequences of human activity on the whole geodynamic system of the Caucasus are discussed. Geography of glaciers, glacial melting, avalanches, cryogenic processes, classification of periglacial formations and impact of cryogenic processes are studied.

Keywords: Glaciers, avalanches, cryogenic processes.

1. Glaciers

In the mountains of Georgia there are about 786 glaciers registered, with a total area of about 550 km^2. About 82.5% of them are in the upper courses of the Kodori, Inguri, Rioni, and Tereck rivers. For the past 150 years significant glacier retreat (0.8-1.7 km) and shrinking of their area by 16% have been observed. Since the middle of the 1940s glaciological situation has been characterized by a sharp reduction in the glacial area, but with the simultaneous increase in their number the united glaciers disintegrated into separate smaller ones, although at the same time separate movements have also taken place.

At some trans-shipping sections of the highways of Georgia the material damage due to elemental destructive processes, as snow avalanches and collapses, account for 50% of the total freight turnover of motor transport. About 31% of the territory of Georgia is

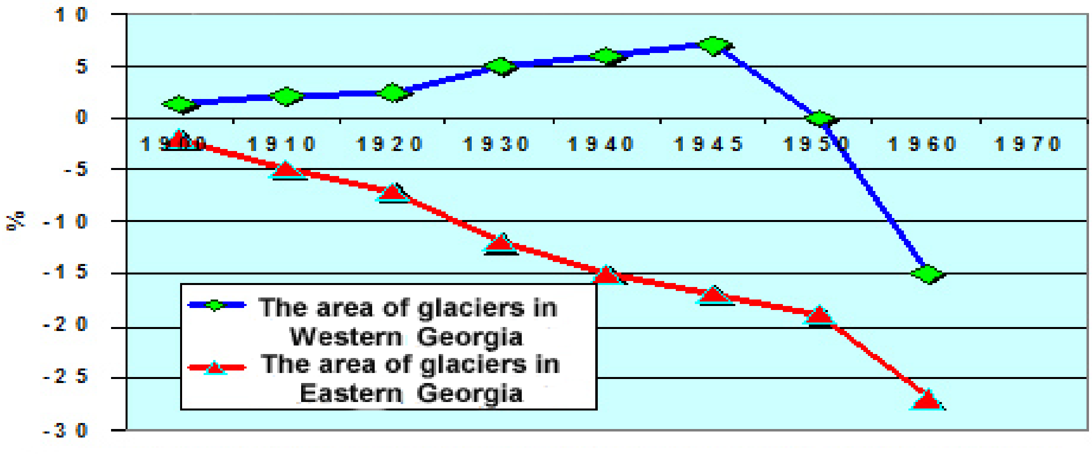

Figure 1. Dynamics of the area of Georgian glaciers 1890-1970 (data at the 1890 year level)

subjected to avalanches (18% in eastern and 13% in western Georgia). More than 70% of the territory is subjected to avalanches in the Terek, Argun, and Assa river basins; about 50% in the Bzibi, Kodori, Chkhalta and Inguri river basins; and up to 25% in the Khobi, Alazani and Iori river basins.

The present day glaciation within the Caucasian region occupies 1436.12 km^2 area and the area is home to 2090 glaciers (per 1993 year data). Glaciation is mainly timed to crests of ridges and adjoining to them are areas of main spurs of the Greater and Minor Caucasus. The total area of glaciers of the Greater Caucasus is 1367.94 km^2 and 99.8% of all glaciers of the Caucasus is situated here (figure 1).

2. Geography of Glaciers

The main glaciations localication of the Terek River basin is Kazbegi-Jimarai massif (Khokhi ridge). Powerful hanging-valley glaciers, Devdoraki, Ortsveri (Gergeti), and Suatisi begin on the walls of this massif. Of all the registered glaciers of Georgia 12.6% are in the Terek River basin with a 12.1% area. Per area hanging-valley type glaciers (48.2%) occupy the first place. Nearly, hanging (17.9%) and corrie (17.1%) glaciers occupy identical areas. The most active glaciers of the Caucasus for the past 100 years are Devdoraki, Abano, and Kolka. The first of these retreated by 16 m during 1881-1970, but the last (Abano) even approached 79 m during 1882-1970. Analysis of the Kazbegi-Jimarai massif data showed that approaching 2000, a reduction in the factor value of the masses of glacier pressure on the strata of the Earth's crust was observed (figure 2). It has been calculated that for a period of 1881 to 2000, in connection with melting of glaciers, this value (k) reduced from 75.0 up to 49.4. With the provision for the given factor the pressure of glacier masses upon the Earth's crust was estimated down to 100 km depth, with the use of the method of end elements in the plan of its lineal setup.

Figure 2. Glaciers in valley Truso (basin to Terek River)

3. Glacial Melting

Our aim is not to seek the reason of active melting of glaciers of the Greater Caucasus whether it is global warming of climate or a consequence of human activity but only try to define their possible consequences on the whole geodynamic system of the Caucasus. However, the size of this geoecosystem is so enormous that may be reasonable to consider only one of its the most representative cells – Kazbegi-Jimarai block. This choice is determined as well by a well known Karmadoni event of September 2002. The area of glaciation on Kazbegi massif forms 23.2 km^2, an average thickness of ice is 45.7 m, ice volume – 1,5063 km^3 (Panov,1993). Calculation of data on the Kazbegi-Jimarai massif shows that approaching 2000 reduction of factor value of glaciers' mass pressure on the rock mass of the Earth's crust was observed (figure 3). It was calculated that from 1881 to 2000 (k) this value was reduced from 75.0 to 49.4. Taking into consideration the value of this coefficient the value of glacier's mass pressure on the rock mass of the Earth's crust to the depth of 100 km was calculated. Estimation of the problem was carried out by the method of end elements in the plan of its linear formation. Provisionally the maximum average density of rocks was accepted as 0.3 t/m^3.

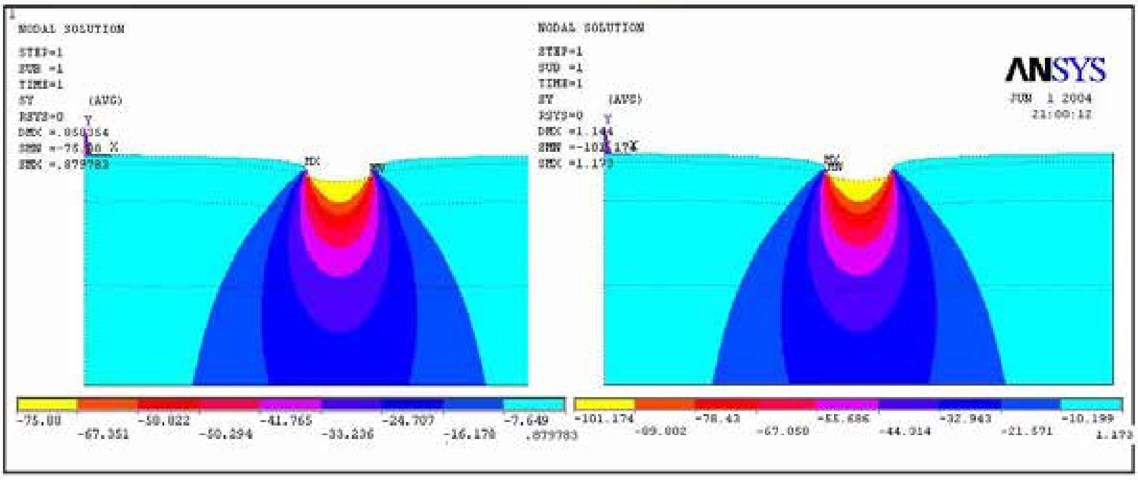

Figure 3. Dependence of loading on Earth's crust taking into account weight of glaciers of the Kazbegi-Djimara file

Here the module of deformation E deformation = 2 h 106 t/m^2, and the Poisson factor u = 0.2. As a first approximation, using computer processing of the data (support program ANSYS) on the material a factor of glacial load on the basement rock surface had the following distribution per vertical: In 1875, the pressure on the basement rock was 65 t/m^2 at a depth of 5 km, 56.9 t/m^2 at a depth of 10 km, 43.59 t/m^2 at a depth of 25 km, 32.39 t/m^2 at a depth of 50 km, and 26.29 t/m^2 or 2.62 kg/sm^2 at a depth of 100 km. In 2000 these values reached 46.39 t/m^2 at a depth of 5 km, 35.59 t/m^2 at a depth of 10 km, 32.9 t/m^2 at a depth of 25 km, 22.89 t/m^2 at a depth of 50 km 17.49 t/m^2 or 1.74 kg/cm^2 at a depth of 100 km. All this points to a significant reduction of pressure upon the Earth's crust of the given region, and consequently to a definite breach of isostasy that must bring about a return reaction, directed at the recovery of balance that in its turn is connected with moving material and energy in this lithodynamic system. Experience shows that removing the pressure from the Earth's crust by means of artificial extraction of significant volume of resources from it (oil and mining, thermal water, bauxite, or kimberlitic mass) brings about a drastic change in the seismicity mode within 5 to 25 years. A classical example is the region of Gazli (Uzbekistan). Therefore, removal of geodynamic load (in the form of glacier masses) can cause an upheaval of endogenic activity.

4. Avalanches

Avalanche-prone periods within the territory under investigation are set mostly during heavy snowfall (50%) and during the melting of snow (29%). A small percent of avalanches accounts for a period of sharp cold snap (8%), rains (4%) and winds. On the territory of Georgia 338 inhabited spots are under the threat of avalanche attacks. As a result of avalanches people lost their lives in 69 of these settlements. They caused destruction in 81 settlements and heavy damages in 58 settlements. The disastrous avalanches spread up to a height of 1500-2000 m above the mean sea level in Colchida and Adjara-Trialeti mountains, up to a height of 2000-2500 m in the Central part of the Greater Caucasus and on its southern spurs, but up to a height of 2500-2900 m in Eastern Caucasus. In January 1987, unprecedented snowfall triggered these avalanches, which had not been observed at any station for a long period of time. Snowfall lasted for 46 days, reaching 16 m thick at a number of places. The accumulated snow in mountains 3-4 times exceeded the usual rate, and on Gagra and Bzibi ranges it exceeded 7-8 times.

If in previous years there were fixed 30-40 avalanches, during 9 to 31 January there 330 avalanches were registered. Many villages in Svaneti were ruined (western Georgia): Chuberi, Ushguli, Mulakhi, Cola, and Khaishi. One of such avalanches covered the village of Zhamushi and carried away lives of 26 people. On the whole 105 people perished in western Georgia during avalanches. Only in the region of Mestia about 210 houses were completely ruined and more than 860 houses were damaged. As a result from avalanche prone regions about 8.5 thousand people were resettled, but the total damage caused was about 300 million $ USA.

On 4 March 2007, a powerful 5 m wide and 200 m long avalanche occurred in the region of Red Glade (western Caucasus, Krasnodar region RF) from the top of Salimovsky circus, burying 4 people, including a child. In February 2007 the Trans-Caucasian highway was already completely closed because of the convergence of tens of avalanches. During a day there occurred not less than 35 avalanches with the general volume of 25 thousand m^3 of snow. In December 2003 heavy snowfall in the Pontides mountains almost blocked 70 villages. One person lost his life.

About 31% of the territory of Georgia is subject to avalanche processes (18% in eastern and 13% in western Georgia). About 70% of the territory in the Tergi, Argun, and Assa river basins is affected by them; about 50% in the Bzibi, Kodori, Chkhalta and Inguri river basins; and up to 25% in Khobi, Alazani and Iori river basins. In January 1987 due to unprecedented snowfall and avalanches 100 people lost their lives.

5. Cryogenic Processes

Cryogenic or periglacial phenomena are widespread in the high mountains of the Caucasian region. The major cryogenic forms of mountainous landscape are depicted in figure 4. The modern area where cryogenic processes spread on the southern slope of the Central Caucasus (Georgia) forms 3.3 thousand km^2, within the Republic of North Ossetia-Alanya – 5.4 thousand km^2, but in Kabardino-Balkaria – 4.6 thousand km^2 (Bondyrev, Maisuradze, 1978). These processes are also widespread on the territory of the Pontides mountains and Iranian upland covering 14.2 thousand km^2 (figure 4).

The factors, defining the genesis and morphology of the forms of periglacial relief changes, depend on the height of the area (table 1). Three hypsometric levels are singled out:

1) The upper belt, which occupies the whole area of nival zone, is limited from underneath by snowline lying at a height of 3000-3200 m above the mean sea level. Here, frost

Table.1

Cryogenic or periglacial phenomena

Formations / Factors Influencing the Formation	**I. Formations confined to the rocky soils**						
		Stone seas and covers	Stone flows and slide-rocks	Developed ridges of mountain ranges	Cave	Nivation formations	Migratory Snowfields
Climate	Modern						1.Blown snowfields 2. Cones of the snow avalanches
Aeolian processes Nivation	Modern	1. Stone mounds 2. Stone barrows 3. Stone covers "Chingils" 4. Stone deposits	1. Mudflow hotbeds and the hotbeds of supply of rock flows	1.Peaks 2. Cracks 3. Furrows 4. Gendarme 5. Couloirs	1. Nivation mines	1. Nivation niches 2. Corridors 3. Nivation cars	
Frost weathering, destruction and desquamating	Modern	5. Stone seas	2. Loose material of fissures and cracks 3. Stone rivers 4. Cones of slide-rocks 5. Kurums	6. Cracks	2. Ice build-ups on the walls and the floor of caves		
Freezing and crystallization	Relic						
Climate	Relic						3. “Eternal snows”
II. Formations confined to coarse-grained soils and gravels							
		Buried snow-firn and ice masses	Thermokarst	Glacio-fluvial	Covers of the surface moraines		
Climate			1. Funnels 2. Slumps		Stone tables		Snow bridges
Freezing and crystallization		Buried ice crust					
Nivation		Buried snowfields			1. Surface moraines; 2. Rocky glaciers		
Frost weathering							Snowy shafts - Pseudomoraines
Solifluction		The buried glaciers					
Fluvial and fluvioglacial flows			Furrows				
Frost weathering		Fossil glaciers					

III. Formations confined to fine fragmental and gravel soils						
	Polyconal-structural		"Stone Bridge" and banded ground			
Climate	Solifluction					5. Snowfields-migrants
Nivation		Micropolygons: 1. Fragmental-edging poly-gons 2.Singenetic polygons 3. Nets 4. Stone circles in the high moun-tain marshes				
Frost sorting soils in the "freeze-thaw, convection"			1. Stone"bridges" 2. Culled zones 3.Not culled zones 4 Stony "slate"			
Drying		Macropolygons				
Frost weathering		Relic		Masses of fine fragmental and gravel material		

weathering and gravitational talus processes largely take place which play the leading role in the formation of present day relief forms.

2) The middle belt is situated below the snow line and practically coincides with the alpine and sub-alpine landscape zones. The lower border is represented by the upper limit of distribution of forest vegetation and ranges within 1750-2300 m above the mean sea level, depending greatly on the existing specific conditions. Here, slope (solifluction, rock-streams, stone and snow avalanches, talus trains, and mud flows) and plane (polygonal-structural ground, (Figure 5.6) boulder pavement, thufurs) processes of periglacial morphogenesis prevail.

3) Relict cryogenic formations (fluvioglacial deposits and cryoturbation) are spread in the lower belt down to 1400-1600 m above the mean sea level.

Various formations of polygonal ground are distinguished among them. (figure 5). Krasnoslobodtsev [1971] singles out 208 alpine glaciers of different morphogenesis on the side and north spurs of the Lesser Caucasian range within a height of 2800-3000 m above the sea level. These formations are encountered very rarely on the south slopes- there are only 21 of them.

Wide spread morainic mantles and sheets and gravitational talus processes define the existence of numerous «fossil» glaciers (dead ice) on their part testifying the regression of glaciation processes. The value of seasonal freezing of soil ground is an important feature for the determination of main relief forming processes in high mountains. Information on these parameters helps decide engineering-geological, building, agro-biological and other problems.

Bondyrev [1979] theoretically determined the values of seasonal freezing depth for different points in the periglacial areas in Georgia, having minimum information on those areas. For this purpose the formula of Budnikov [1967] was used with some amendments to the high-mountainous relief characteristics, the height of snow cover and influence of wind [Bondyrev, 1979; Bondyrev and Sulkhanishvili, 1989; Bondyrev and Maisuradze, 1982]. Comparison with the records of meteorological year-books of Hydro-meteorological Institute of Georgia on the depth of seasonal freezing showed little discrepancies (not

Figure.4. The most typical forms of nival-cryogenic relief wide-spread in the Caucasian region:
1-6 horn peaks (1 – tooth, 2 – peak; 3 – pyramid, 4 – cone, 5 – dome, 6 – needle), 7 – guards, 8 – nunatak; 9 – lava funnel; 10 – lava cone;11 – snowbank; 12 – fissure; 13 – crevasse; 14 – chimney; 15 – bench; 16 – slab; 17 – cork; 18 – shelf; 19 – balcony; 20 – buried glaciers; 21 – corrie; 22 – blockseas; 23 – ice table; 24 – rock stream; 26 – cones and boulder-trains; 26 – polygonal ground; 27 – solifluction terraces; 28 – solifluctive rampart; 29 – thufurs; 30 – «bald» thufurs; 31 – nival recesses.

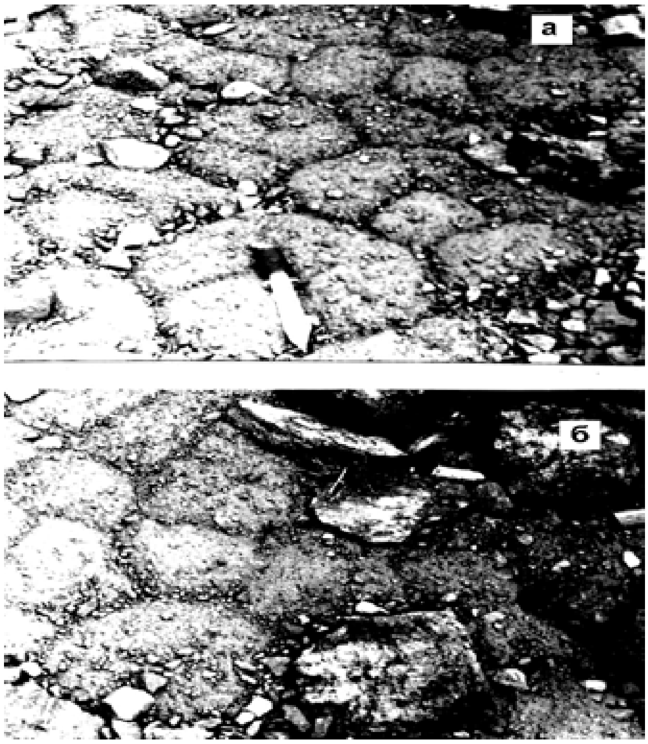

Figure 5. (a) Polygonal forms of south-east slope of Narvan-Khokh massif in plateau Keli; (b) and plain super face Shavdjina, Kazbegi massif

more than 3-6 cm). The records gained are well-founded only for sub-horizontal surfaces deprived of mantle and vegetative cover, with similar mechanical composition and equal humidity value. Calculations were carried using the formula:

$$h_{np} = 5k\left[\sqrt{Tn - \frac{5\ell(n_1 + L)}{t\sqrt{H \times V})}}\right],$$

where $\sqrt{Tn}$ is the Budnikov formula, k is the lithological coefficient, provisionally equal to unity, T is the mean air temperature during winter, t is the mean ground surface temperature during winter, n is the length of the period with temperature below zero, n_1 is the same with temperature above zero during winter, H is the area altitude above mean sea level, V is the winter wind mean velocity, (m/sec), and L is the thickness of snow cover/average for winter [Bondyrev, 1979]. Table 2 illustrates the value of seasonal freezing of soil ground in a number of settlements in periglacial zone of Georgia.

4. Classification of Periglacial Formations

We propose a new approach for classification of periglacial formations, based on «cryogenic formations» as the total cryogenic relief forms are joined by genetic (single mechanisms of formation) as well as regional features (characteristics of underlying surface and characteristics of soils) The given formations are characterized by the following regularities of their spatial distribution:

1) Formations related to the rocky ground occupy the belt of tops, ridges of watersheds and steep slopes of high mountains.

2) Formations related to the fine-ground and pebbles are mainly placed on gentle slopes and at the foot of mountain ridges and massifs within 2700-1900 m above the mean sea level.

Table 2

The value of maximum seasonal freezing of ground in a number of settlements in periglacial zone of Georgia [Bondyrev, 1979]

Settlement	H (Height above s.l.)	Mean winter temperature		*N*	*l*	*Y*	*X*	X_1	X_2
		T	*t*						
Tskhinvali	862	–0,7	–4,1	79	12	12	37	21	20м
Tsalka	1458	–3,3	–5,0	85	24	26	83	73	69п
Gagra ridge	1644	–1,4	–3,0	79	9	20	52	39	-
Omalo	1880	–7,9	–9,7	90	13	5	133	132	-
Lagodekhi	1997	–6,5	–9,3	89	50	30	118	115	-
Goderdzi pass	2026	–7,3	–9,0	90	124	40	130	55	50п
Rodionovka	2100	–10,2	–10,2	90	9	40	131	130	130м
Gudauri	2194	–6,9	–9,6	90	29	10	124	122	-
Ermani	2240	–7,5	–11,3	90	29	26	130	130	-
Jvari pass	2389	–9,2	–12,6	90	38	28	146	146	-
Mamison pass	2854	–11,4	-	90	5	34	160	160	-
Kazbegi	3653	–14,6	-	90	7	40	190	190	-

X – records gained per Budnikov formula; X_1 – our estimated data; X_2 – data of field observations and meteorological stations.

3) Formations related to the fine detrital and rock debris are well observed on the high mountain plateaus in the zone of Neocene-Quaternary volcanism.

4) Formations related to the loamy and turf/soddy/surfaces cover quite a large area, mostly alpine and sub-alpine meadows and alluvial soils of high mountain zone. (See the scheme of classification of periglacial formations of the Caucasus.).

Cryogenic formations of the Pontides mountains are presented by stone mentales and streams, formed of limestones and gypsum rocks (upstream of the Kharashat River) or granitoides (Kachkari massif), occupying steep slopes of watersheds within the range of heights 2300-3000 m above the mean sea level. Rock streams are merged at the foot with trail waste, forming impenetrable heaps. More gentle slopes as well as alpine meadow areas on flat tops are covered by powerful (0.5-1 m) stone placers of great extension (block seas). River valleys of narrow form do not promote the development of cryogenic slope processes there.

Amongst the processes of periglacial morphogenesis the leading role belongs to nivation, broad development of which is stipulated by high humidity. On average about 1000-1200 mm/year precipitation falls in the alpine zone of the Pontides and Arsian mountains.

Numerous snowbanks-pereletoks/intergelisols-are noted in low relief forms (crevasses, fissures, and small troughs) on the slopes of Kachkari massif, Maisis, Onut-daga, Kartsen-daga, Alti-Parmaka, Kvakhidi, and Triali peaks of the Pontides mountains as well as on the massifs of Khirkhata, Arsian, Shavshet (Arsian range). As a result of nivation blocks of shearing are formed similar to those described in mountainous Abkhazia [Bondyrev, 1987]. At places small fields of thufurs, stone circles and solifluctive terraces are noted on the Arsiani range.

Through constant observations in the Mleta polygone (the Aragvi River basin) the velocity of displacement of slope deposits is measured in a wide range (15 to 150 mm/

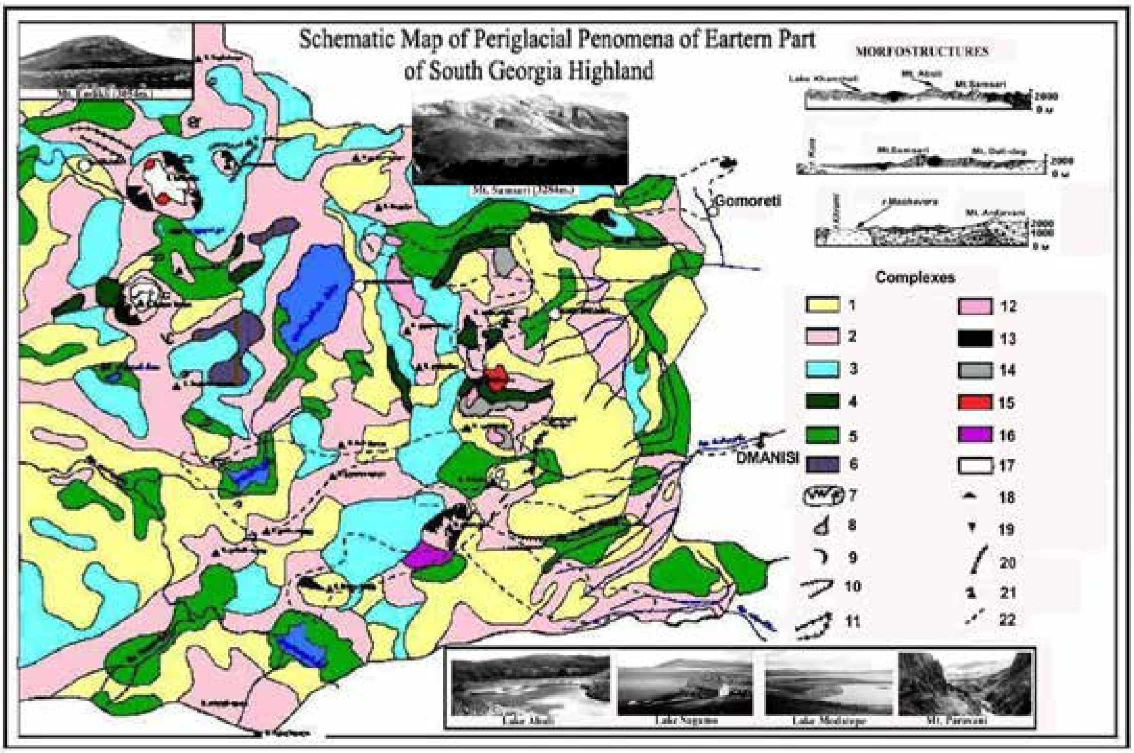

Figure 6. Periglacial Phenomena in the eastern part of Southern Ceorgia (Djavakheti): 1 – Hummochy-solifluccation formations; 2 – Rock streams and talus; 3 – Block seas and mantles; 4 – «Bouldering» and rib boned ground; 5 – Peat-swampy; 6 – Peat-swampy on block seas and alluvial deposits; 7 – At the foot of large volcanic edifices and talus; 8 – Cone and boulder-trains; 9 – Corries and corrie like formations; 10 – Trough valleys; 11 – Lateral benches of lava streams with vector of lava flows; 12 – Snow banks – «pereletoks»; 13 – Buried – snow-firn masses; 14 – Snow hollows and nival recesses; 15 – Thermokarst; 17 – Glacial (relict); 18 – Caves; 19 – Frosty wedges; 20 – Stone walls (anthropogenic) constructed of block seas and mantle material; 21 – Main camp; 22 – Field itineraries.

year) depending on the slope steepness and turfy sheet. At some places solifluctive mudflows are of catastrophic nature, denuding basic rocks. These processes often disturb the integrity of vegetative cover, creating numerous horizontal micro bends on the slopes and furrow landscapes by cryogenic «scars» [Bondyrev, 1978; Bondyrev and Maisuradze, 1978; Iveronova, 1969].

5. Impact of Cryogenic Processes

For estimation of the impact and activity of cryogenic processes upon the natural environment the intensity of their displacement on the slope should first of all be estimated. As per the data of Ivernova [Iveronova, 1969] the intensity of displacement of boulder-train forms 0.029-0.190 mm/year, solifluction – 0.0001-0.170, and debris – 0.003-0.45 mm/year.

The processes of soliflucation and frosty swelling of soils inflict a significant damage, breaking highways and destroying power transmitting lines. The processes of formation of thick clay and loamy series in high mountain regions gave rise to the interest long ago for their genesis and possibility of their use in national economy. Therefore, Bondyrev [1979] conducted a number of experiments studying the rate of frosty weathering in different type of rocks. A core sample No 1 was taken from the well on the Tbilisi site representing the carbonate fine-grained rock of Eocene age (marl), taken at 2574-2580 m

Figure 7. Panorama of the East Caucasus (a kind of image from the south)

depth. The other sample was a monolith of andezite-dacitic lava (SiO2–50%) from the top of Emlikli massif (2750-2800 m above the mean sea level, Southern Georgia).

Table 3

Experimental evaluation of the rate of frosty weathering of mountain rocks [Bondyrev, 1979]

Number of version:	Mean amplitude of temperature fluctuation during the experiment	Area of frozen surface (sm^2)	Initial weight of sample (r)	Weight of frozen sample	Number of «freezing-thawing» cycle	Weight of disintegrated particles.	Velocity of disintegration of frozen surface a day/gr/m^2.a day/	Velocity of disintegration / mm/year/
1 – over-moistured	28.2°C	22.56	31.70	31.74	80	0.73	4.0514	0.288
2 – dry		31.34	41.10	41.47	80	0.07	0.2819	0.040
3 – over-moistured		34.23	41.94	42.03	70	0.53	2.2079	0.672
4 – dry		37.84	25.19	25.45	70	0.10	0.3790	0.047

Conditions, especially similar to those of high mountain natural conditions, were created. Experiments went on for 31 days. About 315 regimes «freezing- thawing» changed one after another. As a result it became likely possible to find the decisions of such issues as estimation of the rate of disintegration of mountain rocks under frosty weathering. Estimated data is given in table 3, estimating the rate of frosty weathering of separate units depending on the lithology of mountain rocks and the extent of their moistening. On the basis that the processes of frosty weathering within the region under study develop almost in similar conditions, it becomes possible to use the estimated data of the experiment for estimation of similar parameters in the natural High Mountains, with allowance for microclimatic peculiarities and making some amendments.

References

1. Bondyrev I.V. (1978). On the tufur's of the Caucasus, in «Cryogenic phenomena's of the Highlands ", Novosibirsk: «Nauka (Science)», pp. 36-42.

2. Bondyrev I.V. (1979). Calculation of seasonal frozen soil-ground in Georgia. Abstracts of the resulting scientific session of the Vakhushti Bagrationi Institute of Geography, Academy of Science of Georgia, Tbilisi, pp. 23-24.

3. Bondyrev I.V. (1987). The main problems of the study and development of the mountain regions of Georgia, Tbilisi: Overview of the State Committee on Science and Technology, 68 p.

4. Bondyrev I.V. and Maisuradze G.M. (1978). Some features of dynamics of morphogenesis and spatial placement of frozen ground in the Caucasus, in «Cryogenic phenomena's of the Highlands ", Novosibirsk: Nauka (Science)», pp. 43-59.

5. Bondyrev I.V. and Maisuradze G.M. (1982). The essay of study and peculiarities of spatial distribution of the frozen-glacial relief forms, beyond the Caucasus border. «Quaternary System of Georgia», (XI Intern. Congr. Quater. Moscow, 1982), Tbilisi, Metsniereba, 74-88 p. (in Russian).

6. Bondyrev I.V. and Sulkhanishvili G.S. (1989). Experimental study of mechanics of frost weathering of mountain rocks. Bull. Tbilisi Polytechnic Univ., Sufl. «Hydrogeology and Engineering Geol.», № 12 (354), pp. 19-25 (in Russian).

7. Iveronova M.I. (1969). Experience on contemporary of the quantitative analysis the denudation processes. Proceedings of the Academy of Sciences URSS, Ser. «Geography», № 2, pp. 34-39.

8. Krasnoslobodtcev I.S. (1971). The stone glacier's the Great Caucasus // «Messenger of the Moscow State University», № 1, pp. 95-96 (in Russian).

ЛЕДНИКОВЫЕ И ПЕРИГЛЯЦИАЛЬНЫЕ ПРОЦЕССЫ ГРУЗИИ

© 2013 И.В. Бондырев

Тбилисский государственный университет им. И. Джавахишвили, институт географии им. Вахушти Багратиони, 0179, г. Тбилиси, Грузия, пр. Чавчавадзе, 1, e-mail: example@tsu.ge

В горах Грузии зарегистрировано около 786 ледников. Обсуждаются возможные последствия человеческой деятельности в целом геодинамической системы на Кавказе. Изучены география ледников, таяние ледников, лавин, криогенные процессы, классификация перигляциальных образований.

Ключевые слова: ледники, снежные лавины, криогенные процессы