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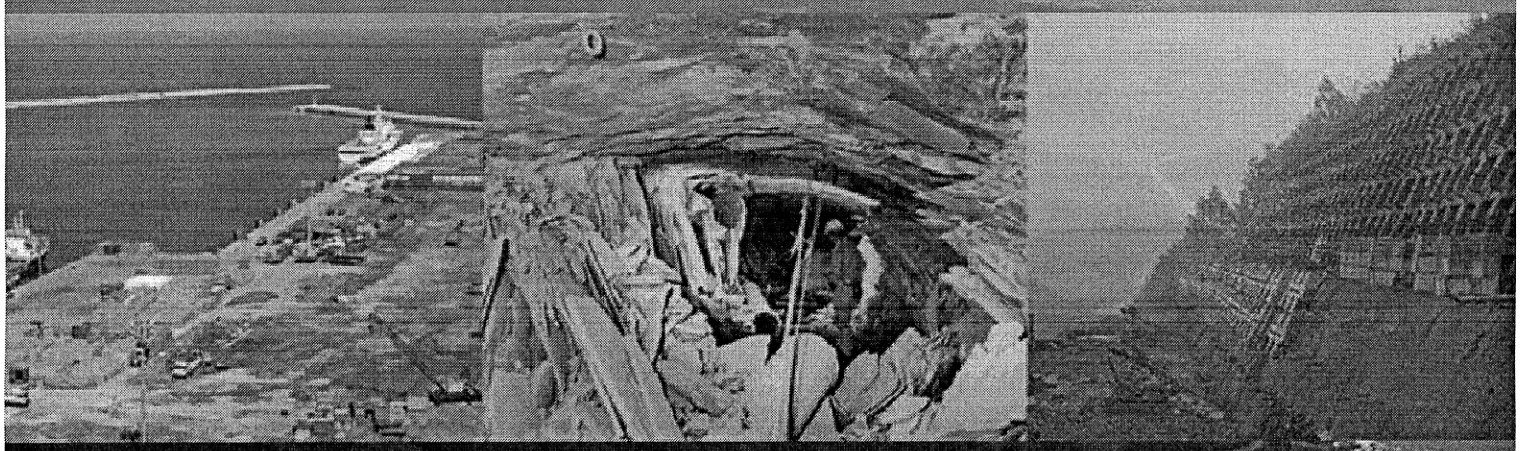

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Debris Flows in the USSR and in Russia

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Abstract

In the 1860s. first expeditions were organized to study the origins of ice-rock collapses that were blocking the trans-Caucasian road. The late 1950s – late 1980s were "the golden thirty years" of the Soviet debris flow science. A Debris Flow Commission under Academy of Sciences was established. Manuals for researching and monitoring debris flows were written. Various constructions for debris flow protection were built. Stations for debris flow monitoring and research were operating. After the collapse of the USSR.

Debris Flow Commission has stopped his work; debris flow observations were practically reduced. Debris flow disasters of the early 21st century in the Caucasus have attracted attention to this field. In 2005, the Debris Flow Association (DFA) was established in Russia as a professional society. A debris flow bibliography for 1968-2005 is being prepared for publication. It was held the expeditions at the mountain Kazbek, at the mountain Elbrus and to the Kolka glacier. The analysis of debris flow manifestations of last years and the decisions on engineering protection from them were presented at international conferences in Russia, Switzerland, Spain, Nepal, Austria and Greece.

Keywords: *debris flows, mudflows, Russia, Soviet Union, research*

1 Introduction

Sometimes it happens that a whole period of learning and knowledge sinks into oblivion. For a long period a phenomena is intensively studied, but then hard times come and the tradition is lost. Then a new generation comes and starts all over again. It happened the similar with debris flow research in Russia and the countries of the former USSR.

Decades of research within a large unified country, and generations of experts contributed to development of *selevedenie*, the Soviet debris flow science. Then the USSR was dissected by boundaries of the new states, and opportunities for collaboration diminished. Research programmes aimed at a systematic approach within large state-funded projects were replaced by smaller national studies. In several countries the debris flow problem kept its priority, in others it was no longer considered important. The economic crisis of the 1990s has abruptly reduced research funding. Multi-year observation sequences were stopped, many researchers had to seek jobs outside science.

Our goal is to recall the previous experience, follow the main development stages of the debris flow science and assess the contemporary state of the field. The authors, representatives of Russian Debris Flow Association are engaged in debris flow research, mainly in the Caucasian mountains, and have published about hundred articles on the related topics.

We are not the first to attempt such a review, but follow earlier examples of I.V. Bogolyubova (1957), and Fleishman (1978). However, the situation has changed significantly and shall be analyzed.

The Russian debris flow literature numbers some 5500 works. And the volume of this paper does not allow listing even all of the most important studies.

2 When the humankind first encountered debris flows?

In all probability, it happened when people started to build homes and trade roads in mountains.

Homer, in 8th century BC, wrote in Iliad (the Song 21): "…fill your streams with water from their sources, rouse all your torrents to a fury; raise your wave on high, and let snags and stones come thundering down you…" (Homer, 2003).

The Bible also mentions debris flows several times. E. g. in Job we read: "Who has the wisdom to count the clouds? Who can tip over the water jars of the heavens when the dust becomes hard and the clods of earth stick together?" (Job, 38: 37-38). In the same place we also read: "But as a mountain erodes and crumbles and as a rock is moved from its place, as water wears away stones and torrents wash away the soil" (Job, 14: 18-19).

Some of the debris flow dates are recorded in ancient sources. E. g., in 79 AD in Italy during the eruption of Vesuvius, described by Pliny the Younger (The letters..., 1984) a volcanogenic debris flow formed and covered the streets of the town of Herculanum.

The Roman philosopher Seneca wrote in 1st century AD about a future debris flow disaster which could happen (in modern terms) under joint action of an earthquake, a tsunami and an extreme rain. As a result of increased wetness, the earth would crumble, and rot, then spread about as a liquid mud. Then rivers will emerge from the mountains and will shake the mountains by their mighty force, then will flow further, spilling over the banks (Seneca, 2001).

Naturally inhabitants of the mountainous Caucasus experienced debris flows from time, and consequently their literature heritage mentions large stones carried by water. E.g. in the Georgian epic about *the Knight in the Panther's Skin* (12th century) we read: "The stones stepped out of the river, weeping" (Rustaveli, 2002). The medieval Nart sagas describe how the Kuban river braches its banks "moving about and tumbling stones size of a house, the stones collide, we hear rattle and thunder" (Nart Sasrykva..., 1988).

In 16th century Leonardo da Vinci referred to the indescribable damages brought by the mountain rivers breaching their banks (Leonardo da Vinci, 1955).

As for the scientific studies of debris flows, it is customary to list the works of J. Fabre (Fabre, 1797) and A. Surrel (Surrel, 1841).

3 The Georgian Military road and the beginning of Russian debris flow studies

The way crossing the Caucasian mountains through the valleys of Aragvi and Terek Rivers has been known for several millennia. In 1 century BC the Roman geographer Strabo wrote: "From the Nomades on the north there is a difficult ascent for three days, and then a narrow road by the side of the river Aragus, a journey of four days, which road admits only one person to pass at a time (Strabo, 2004). Pliny the Elder in the 1st century AD noted: "After passing the last, we come to the Gates of Caucasus, by many persons most erroneously called the Caspian Passes; a vast work of nature, which has suddenly wrenched asunder in this place a chain of mountains. At this spot are gates barred up with beams shod with iron, while beneath the middle there runs a stream which emits a most fetid odor (Pliny the Elder).

In early 19th century the South-Caucasian lands were added to the Russian Empire. The only way through the Caucasus range was the ancient road through Aragvi and Terek. As the traffic grew, it was improved, fortified and named the Georgian Military road.

Russian military and civil authorities faced the problem of glacier disasters, caused by the Devdorak glacier on the slope of Mt. Kazbek. Each time after the ice blockages (registered in 1776, 1778, 1785, 1808, 1817 and 1832) the traffic along the Georgian Military Road was interrupted for a long period of time. These disasters were a subject of detailed scientific study by the commission of Boleslav Statkowsky (fig.1). He organized the first debris flow expeditions. B. I. Statkowsky introduced a term "sel" (debris flow) (Statkowsky, 1859). In a later paper in 1997 he writes: "Let me describe one astonishing phenomena which is not rare in the mountains, the phenomena which no protective structures can withstand, and which is commonly named "discharge" or "sel' in the Caucasus, While in the Alps it is called "Nante", "Nante sauvage" and "cone de dejection". Usually these follow a thunderstorm in the mountains, when certain gullies, which have favorable location to produce the phenomena, eject great masses of rocks, stones, and mud. These entrain everything on their way, and stop the transportation on the roads, sometimes for a long period of time (Statkowsky, 1877).

The current meaning of the term "sel" in Russia includes both debris flows and mudflows.

In late 19th –early 20th century, experiments on forest planting for debris flow protection were conducted in the Caucasus by B. N. Lisnevsky and in Central Asia by S. Yu. Rauner. Consequences of several debris flows were studied by M. P. Psarev and K. I. Bogdanovich.

Catastrophic debris flows attracted attention of the experts in the Soviet Union. One of these flows took place in the city of Almaty in 1921, leading to significant distruction, and a flow in the river Adyr-Su valley in the Caucasus, which destroyed two mountaineering camps. Debris flows were studied in the Caucasus, the Carpathians, the mountains of central Asia and Siberia, in Kamchatk Peninsula etc. Properties of debris flow mass were studied in Laboratory (I. G. Esman), the most dangerous debris flow basins were surveyed and studied (A. F. Verzhbitsky), and protective measures for roads and infrastructure were designed (A. L. Brilinsky).

4 "The golden decades" of the debris flow science

The most active research started in the second half of the 20th century, when construction in mountains became widespread.

In 1947-1991 a Debris Flow Commission of the Russian Academy of Sciences and the State committee on science and technology of the USSR Council of Ministers coordinated the debris flow science. It organized conferences, published proceedings and books on the state-of-the art research. The Commission was chaired in different years by M. A. Velikanov, M. F. Sribny, S. M. Fleishman and Yu. B. Vinogradov. After a number of catastrophic debris flows, methods for debris flow studies were developed and manuals published, e.g. Manual for comprehensive study of debris flows (M. V. Churinov and A. I. Sheko, 1971), and also Manual for study of debris flows (Rukovodstvo..., 1976) et al. assessment of debris flow hazards was introduced into the Construction norms and regulations (SNiP..., 1982).

24 debris flow conferences were organized in 1949-1982. The topics of conferences were wide ranging, from universal debris flow forums to meetings on specific questions such as: protection of rail roads; methods for study and forecast of debris flows, rockfalls

and landslides; work of debris flow monitoring stations; measures against irrigation erosion and debris flows; methods of debris flow mapping; design of protective infrastructure.

The late 1950 – 80s can be considered 'the golden thirty years" of the Soviet debris flow science. A strong 'Soviet school' of experts was formed. These worked in ministries, institutes, universities, science academies and hydrometeorological service. Debris flows in all territories of the USSR were studied, including: Azerbaidjan (I. I. Mechitov, B. A. Budagov, S. G. Rustamov), Armenia (I. V. Yegiazarov, V. Sanoyan, R. G. Asotryan, M. V. Tsovyan), Georgia (M. S. Gagoshidze, K. R. Begishvili, I. I. Kherkheulidze, G. M. Beruchashvili, V. I. Tevzadze, D. D. Tsereteli, E. D. Tsereteli, G. I. Kherkheulidze), Kazakhstan (Yu. B. Vinigradov, A. P. Gorbunov, A. Degovets, N. S. Dyurnbaum, S. P. Kavetsky, V. P. Mochalov, G. D. Rozhdestvensky, b. S. Stepanov, R. V. Khonin), Kyrgyzstan (M. I. Iveronova), Russia (I. V. Bogolyubova, A. V. Yermakov, E. V. Zaporozhchenko, V. Ye. Ioganson, V. K. Laperdin, V. F. Perov, I. B. Seynova, M. F. Sribny, Yu. B. Trzhcinsky, S. M. Fleishman, A. I. Sheko), Uzbekistan (F. K. Kocherga), Ukraine (M. M. Aizenberg, B. L. Velichko, B. M. Ivanov, A. N. Oliferov), Tadjikistan (I. A. Mossakovskaya, O. V. Tukeev, M. R. Yakutilov), Tukmenistan (N. M. Trofimov). This list is far from complete. The larger debris flow conferences attracted as many as 300 experts.

The designs developed in the USSR were used to build various constructions for protection against debris flows. Stations for debris flow monitoring and research were operating in Zailiysky Alatau, Caucasus, and in the Crimea.

In Kazakhstan a special body called 'Kazglavselezashchita' was created to build protective constructions. These included dams on the Great and Little Almatinka Rivers which on many occasions produced debris flows damaging the city of Almaty. In the 1970s experimental artificial debris flows were created in the Chemolgan River basin, as described by Vinogradov (Vinogradov, 1980). In Georgia a large dam was built to protect the town of Kvareli, where debris flows took over 200 lives in a hundred years. In the same region, mesh-like protective constructions were built to protect the town of Telavi. In the Northern Caucasus leading in this system of 'Minvodhoz RSFSR' (Ministry of Water Supply in Russian Soviet Federative Socialist Republic) "Sevkavgiprovodhoz" Institute was engaged in design of debris flow protection constructions.

5 Problems of late 20th –early 21st century

The collapse of the USSR (1991) has divided the debris flow community by the new state boundaries. The Debris Flow Commission stopped to function. The economic crisis of the 1990s and abrupt fall in research funding were an additional blow. The debris flow observations in Russia were practically ended. Many institutes stopped debris flow research.

Large debris flow disasters in the Caucasus at the turn of the millennia, such as catastrophic flows in the Gerkhozhan-Su river basin in 1999 and 2000, numerous debris flows in June and a glacier disaster in September 2002 in the Genaldon river valley have attracted attention to this field again. Currently the debris flows in Russia are studied and monitored by such organizations as the Ministry for Emergency and Disaster Mitigation, regional geological monitoring offices, the Sevkavgiprovodhoz design and Planning Institute, Moscow State University etc. New books in the field have been published (Chernomorets, 2005, Zaporozhchenko, 2006 et al.). Debris flow expeditions are being arranged. After a long interval, three debris flow conferences were organized in Russia (Vserossiiskaya…,2002, Zashchita…, 2004, Tezisy…, 2005).

Nevertheless, the debris flow research community was not reunited until recently. Organization and individual experts did not coordinate their work. The world debris flow conferences in recent years in San Francisco, Taipei and Davos have demonstrated that this science has considerably advanced. This in particular concerns such fields as field measurements of debris flow parameters, flow modeling, design and construction of protective structures.

6 Debris Flow Association

Recently the coordination of debris flow research in various organizations started to be perceived as an acute need. For several years, the reinstatement of the Debris Flow Comission was discussed. On the initiative of a group of experts a Debris Flow Association (DFA) was founded in Russia in 2005, as a professional society of experts (scientists and practitioners) for effecting and supporting activities in the field of debris flow and natural hazards studies, development of assessment and mitigation methods, and the population protection. This society has now been joined by experts from Kazakhstan, Georgia, Azerbaijan, Armenia, Canada, Italy and Taiwan. The DFA website is at: http://www.rsk.land.ru/index_eng.htm.

Under the auspices of DFA, a Russian debris flow bibliography for 1968-2005 is being prepared for publication. About 1700 Russian works were published on this topic in 1850-1967 (Vlasov and Krasheninnikova, 1969). In the contemporary period (1968-2005), according to the estimates of A. Yu. Vlasov, about 4000 further Russian works were published.

It is planned to review and modernize the debris flow manuals. DFA has started the discussion on the creation of a large-scale programme on the debris flow study and mitigation, which would enable to study the current state of the danger areas, educate new experts, create modern monitoring networks, improve forecasts and ensure the population safety.

The representatives of DFA participated with papers at the internationals conferences in Saint-Petersburg (Russia), Saragossa (Spain), Katmandu (Nepal), Vienna (Austria) and in the island Rhodes (Greece). Several films on debris flow events of last years in the Northern Caucasus were created. Debris flow expeditions jointly with Caucasian Mountain Society were organized in the region of Mt. Kazbek (Russian – Georgian expedition in 2005, Russian expedition in 2006) and Mt. Elbrus (Russian – Spain expedition, 2006). The first expedition permitted to estimate the situation at Devdorak glacier: there is no reason for concern about catastrophic mudflow in the future caused by morphologic changes in the ice approach of glacier after its recession by ~ 400 m. during 130 years

The second expedition on the contrary revealed the pre-catastrophe situation at the Birdjalychiran glacial lake (the total storage is 550 000. m³) on the northeast slope of Mt. Elbrus. Its emptying inevitably would cause mudflows possible to reach national Djily – Su health resort with devastating results (figure1, 3).

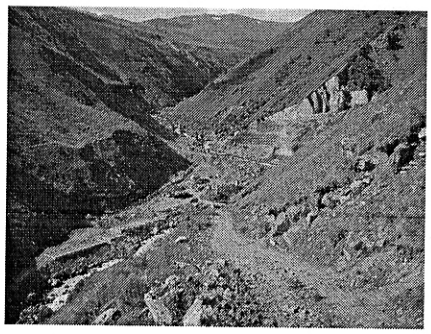

Figure 1. July 27, 2006. "Djily – Su" area before debris flow, august 11, 2006. Photo by E. Zaporozhchenko.

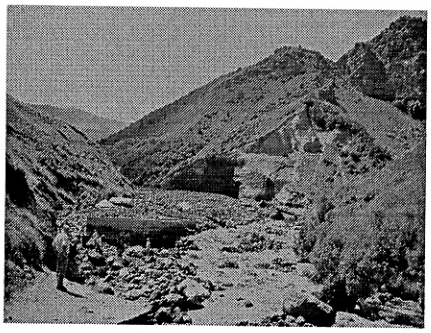

Figure 2. August 13, 2006. The same after debris flow. Photo by E. Zaporozhchenko.

The administrative and the state government of Kabardino-Balkarskaya Republic have been immediately informed about menacing danger to the functioning state medical improving complex "Djily – Su". On August, 11, 2006 the event happened that should take place: washout of glacial dam at a height of ~3300 m (photo 5), emptying of water body (photo 6) and forming of powerful mudflow which has drift floods of mineral sources (~2300 m of absolute altitude) and bathes existing there, it has destroyed all infrastructure about riverbed (buildings, roads, bridge and other). The only thing that mother-nature permitted herself to regret people wishing healing: debris flow has covered the gorge at 4 o'clock in the morning, when there was nobody at bathes and close to mineral sources (photo 2, 4). Otherwise it would not be avoid human victims!

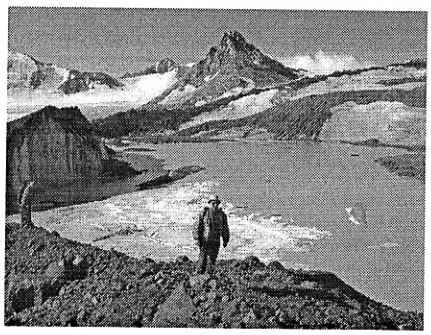

Figure 3. July 28, 2006. East Upper Birdjalychiran lake before emptying. Photo by E. Zaporozhchenko.

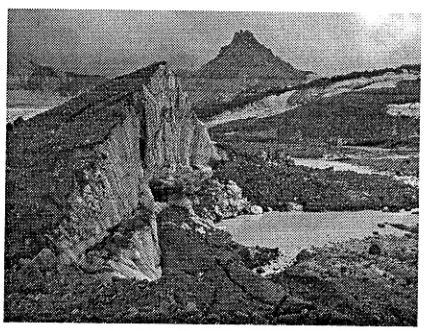

Figure 4. August 22, 2006. The same after emptying ~ 400 000m³ through glacial dam (to Q 150 m³/s. Photo by K. Korikov.

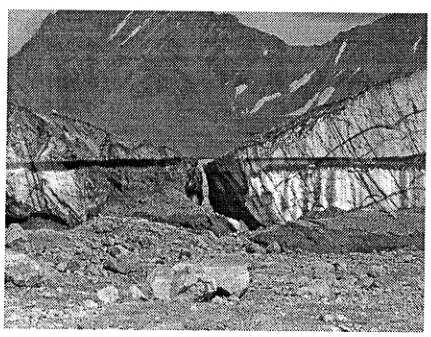

Figure 5. August 22, 2006. East Upper Birdjalychiran lake. View of bottom in the time of level discharge of 8,5 m through washout (chap) in glacial dam. Photo by K. Korikov.

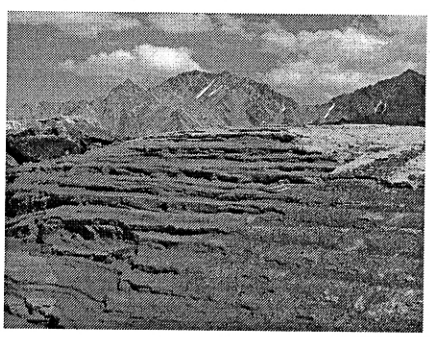

Figure 6. August 17, 2006. Natural course of East Upper Birdjalychiran lake emptying is reflected by coast microterraces of head. Photo by S. Chernomorets.

The expedition to the Kolka glacier (RSO - Alania) in 2006 is held for clarifying of character of the processes caused by a rapid movement of the glacier (09. 20. 2006 125 persons died) and by debris flow. Its aim was to define degree of danger for population and for subordinated territory was for the near future.

Association plans to organize an international conference on debris flows and protective measures against them in Russia in September, 2008. (Pyatigorsk).

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