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Activation of Dangerous Natural Processes on the Territory of the Kabardino-Balkarian and Karachay-Cherkess Republics

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Abstract: The paper considers the manifestations of dangerous natural processes and their consequences in the territories of two republics – the Kabardino-Balkarian and Karachay-Cherkess Republics for the period from 2015 to 2022. On the basis of the collected material, an analysis of the manifestations of hazardous natural processes was carried out and maps-schemes were compiled.

Keywords: hazardous natural processes, monitoring, floods, mudslides, atmospheric (stormwater) precipitation, GPS-survey, schematic map.

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1. Introduction

Currently, on the northern slope of the Greater Caucasus, especially in the Kabardino-Balkarian (KBR) and Karachay-Cherkess (KChR) Republics, the activity of hazardous natural processes is observed [*Kyul et al.*, 2019b]. Therefore, the assessment of the impact of hazardous natural processes on the transformation of geosystems becomes an urgent and priority task.

At the same time, large-scale and long-term work in the study area in recent years has practically not been carried out on this problem. A number of works on mudflow issues published during this period, in most cases, were largely based on data from the 80s–90s of the 20th century, incl. and Cadastre of Mudflow Hazard in the South of the European Part of Russia [*Kondratieva et al.*, 2015]. Therefore, the Center for Geographical Research of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences (KBSC RAS), starting from 2011, along with fundamental research into the dynamics of geosystems, resumed geoecological monitoring of hazardous natural processes, in particular, mudflows and nanowater floods, which was almost completely stopped in the 1990s. years of the XX century. A number of similar articles were published on some selected geosystems of the northern slope of the Greater Caucasus [*Kyul et al.*, 2022, 2021a].

2. Materials and methods

The article presents data both from the analysis of the descent of hazardous natural processes, taken from electronic sources, and data obtained in the course of field research. At the same time, the collection and analysis of data during the monitoring of hazardous natural processes was carried out according to the methodology developed by the authors [*Kyul et al.*, 2019a; *Kyul and Borisova*, 2015].

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3. Results

The need to conduct field work to monitor the manifestations of hazardous natural processes is confirmed by the news about them constantly coming to the media. The most serious consequences caused by heavy rainfall were observed in 2015, 2018–2022 (Table 1).

Table 1. Mudslides and floods on the territory of the KChR for the period from 2015 to 2022.

Administrative district	Highway	River basin	Hazardous natural processes (HNP)	Date of manifestation HNP	Consequences of the descent HNP [Kyul et al., 2021b]
Malokarachaevsky			Flood	07.06.2022	50 yard plots were flooded, water entered 19 houses
Malokarachaevsky	"Pyatigorsk – Karachayevsk"	Podkumok	Mudflow	07.06.2022	A section of the road on the 71st kilometer "Pyatigorsk-Karachayevsk" was damaged
Karachay city district	"Cherkessk – Dombay"		Mudflow	05.06.2019	Skidding of the highway on 77 km of the Cherkessk-Dombay highway. The volume of the mudflow is about 30 m^3
Zelenchuk		Bejgon	Flood	18.06.2018	The bridge over the Bejgon River was washed away by a flood of water
Karachay city district		Amanauz	Flood	05.07.2017	The children's camp "Adel" was flooded, 80 people were evacuated
Zelenchuk	Kuban – Khudes – Bichesyn	Podorvanka	Flood	18.06.2016	The bridge over the river was destroyed Podorvanka
Zelenchuk			Mudflow	01.07.2015	Roads are washed out, household plots are flooded. One person was killed, two were injured
Urupsky			Mudflow	01.07.2015	

For example, on the territory of the Karachay-Cherkess Republic, on July 1, 2015, numerous mudflows occurred in the Zelenchuksky and Urupsky districts, caused by heavy rains. The elements dealt a powerful blow to settlements as well. Roads were washed out, household plots were flooded. One person died, two were injured (Figure 1) [*Kyul et al.*, 2019a, 2021b].

Mudflows descended in Urupsky, Zelenchuksky and Karachaevsky districts on June 16–17, 2018. In the village of Kurdzhinovo, 110 farmsteads were flooded, mud flows blocked the Karachaevsk-Uchkulan road. The dam on the Khusa River in the village of Zelenchukskaya and the approach to the pedestrian crossing over the Bezhgon River in the village of Storozhevaya are washed out. Mudflow descended in the village of Khasaut-Greek. More than 500 households, a school and a kindergarten were flooded in the village of Pregradnaya. The mudflow that came down between the villages of Upper Teberda and Lower Teberda blocked about 100 m of the road (Figure 2).

Dangerous natural processes make land plots unsuitable for national economy. In this regard, in the summer of 2019, after the passage of heavy rainfall in the study areas, we examined some river basins and adjacent settlements in the territories of the KBR and KChR. Based on the results of field trips, a table of hazardous natural processes was compiled with photographic material and their binding by coordinates, which makes it possible for us to monitor these areas (a part is given) (Table 2).

Figure 1. Consequences of mudflows in Zelenchuksky and Urupsky districts of the KChR on July 1, 2015 [*Kyul et al.*, 2021b].

Figure 2. Mudflow descent along the left tributary of the Teberda River to the federal highway "Cherkessk-Dombai" on 06/16/2018 [*Kyul et al.*, 2021b].

Also, based on the results of field trips, schematic maps have been compiled, with GPS points applied (for example, Figure 3).

All the places where the road intersects with streams (waterways), drifts and erosion of the highway are recorded. The wooden bridge over the Zagedanka River is in disrepair – the bridge supports are clogged with karch, the banks are washed away. The floodplain forest is flooded. Traces of mudflows of small volumes are visible. The dirt road on the left side of the Bolshaya Laba River from the village of Damkhurts to the village of Rozhkao suffered more from the rains. Mudflows of 50,000 m^3 were observed in the Damkhurts River basin (a wooden bridge was destroyed). Below the Karapyr cordon in the area of the stream, the left tributary of the Bolshaya Laba River, there is a drift and erosion of the road. On the entire left side, as a result of surface washout, the roadbed was damaged (2 landslide massifs). Fresh mudflow deposits are visible in the Zakan river basin. The bridge across the Zakan River is in disrepair. At the intersections of the road with streams (observation points 1110, 1114, 1127), the canvas is completely washed out (traces of backfilling are visible). Above the village of Rozhkao, opposite the bridge, there is a mudflow cone with fresh mudflow deposits at the mouth of the right tributary of the Bolshaya Laba River. The bridge is in disrepair (washed out river banks). The basin of the Rozhkao River, the left tributary of the Bolshaya Laba River, is also mud-bearing: traces of microflows (washout and bank collapse). Below the village of Rozhkao, a mudflow fan is observed at the mouth of the right tributary of the Bolshaya Laba River. The riverbed is divided into 3 branches

Table 2. Areas of manifestation of hazardous natural processes on the territory of the KChR according to the data of the Central Geological Survey.

№ points	Binding	Coordinates N	Coordinates E	Marks	Height
	Karachay-Cherkess Republic				
	Teberda. The exit point of the mudflow to the road.				
564		43° 38.814'	41° 53.041'	±4 m	1036 m
	Uchkulan. The collapsed bridge.				
930		43° 27.571'	42° 05.878'	±2 m	1362 m

(under the road bed there are mudflow trays clogged with fresh mudflow deposits, the possible volume is more than 50,000 m^3). As a result of the mudflow along the right slope (observation point 1161), a mudflow was formed. Throughout the entire length of the road on the starboard side (observation points 1162–1172) traces of floods are observed (the road is partially at the level of the river, it was flooded in places). Clearing traces are visible, the floodplain forest is flooded. As a result, a number of landslide massifs formed along the right slope.

The left side of the Bolshaya Laba river. Below (observation points 1173–1179), the road crosses the mudflow fan at the mouth of the right tributary of the Bolshaya Laba River and goes to the left side. In the Asian village (above the village, in the village itself and below the village), there were thin mudflows along the right tributaries. In the area of the village of Kurdzhinovo, the right-bank part (observation point 1195), due to the low level of the road, a section 50 m long was flooded. In the area of the village of Psemen (the Psemenka River, the right tributary of the Bolshaya Laba River), traces of the flood are visible (erosion of the banks and undermining of the bridge supports). In the left-bank part of the village of Kurdzhinovo in the basin of the Beskes River, the left tributary of the Bolshaya Laba River, there are fresh mudflow deposits in the estuarine part (a landslide zone was formed along the left slope, within which residential buildings and part of the road turned out to be).

In general, it can be concluded that many dangerous natural processes take place in the Bolshaya Laba river basin. Nival-glacial processes are developed in the upper reaches of the mountains. Mudflows are the main process. Almost all major tributaries of the Bolshaya Laba are mud-bearing. Mudflows are recharged not only because of avalanches, but because of the widespread development of landslide-scree and less often landslide processes, which are often of an anthropogenic nature. The peak of mudflow activity falls on summer time (July). Mudflows and floods, mainly of rain genesis. Due to the good development of the territory, almost all areal and linear economic objects fall into the zone of action of hazardous natural processes.

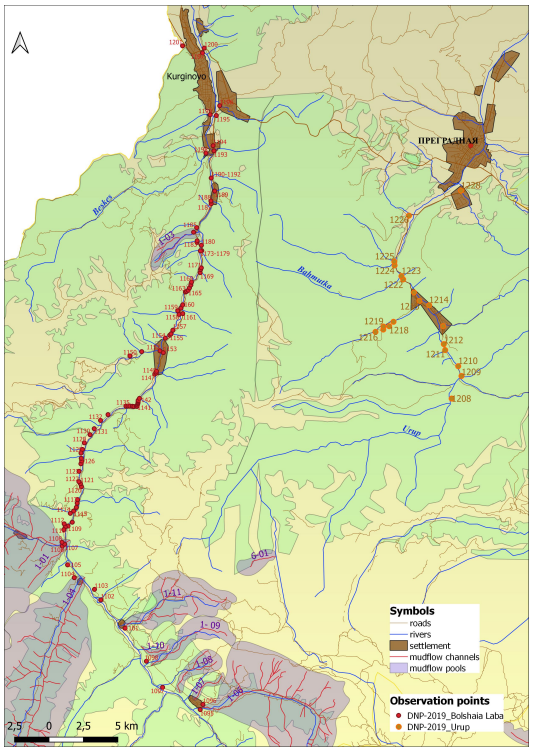

Figure 3. Map-scheme of the actual exposure to natural hazards of linear facilities in the Bolshaya Laba and Urup river basins (KCR).

Urup river basin. In the area of the Trout farm, along the right tributary of the Urup River, erosion of the banks and flooding of the floodplain forest are recorded. Below the Sebeldinka River, the right tributary of the Urup River, on the old alluvial cone at the mouth of the river, fresh mudflow deposits are visible (the dirt road is covered and washed out). The bridge across the Urup River is in disrepair (bank erosion and undermining of the bridge supports). On the left side of the Urup River, in the zone of action of hazardous natural processes, in addition to the road, there is the building of the Urup plant (mine) and a mining village. In the basin of the Vlasenchikha River, the left tributary of the Urup River, (adits and treatment facilities with an industrial site), as a result of mining activities, an anthropogenic zone (a number of tenogenic landscapes) was formed with the development of subsidence processes. On all left tributaries, traces of floods are observed (bank erosion, motorway skidding). The bridge over the Urup River (observation point 1226) is in disrepair. Fresh mudflow deposits are noted in the riverbed. Fresh mudflow deposits are observed on the Urup River and its right tributary, the Seroshtanka River. There is an activation of coastal erosion (bank erosion). Floodplain forests are flooded due to rising water levels in the river. On the left side of the Urup River, below the village of Mednogorsky, an anthropogenic zone has been formed, namely: a tailing dump is located, which is at the stage of reclamation.

It can be concluded that the mudflow process is the leading process in the Urup river basin. Mudflows – rain and less often anthropogenic genesis (within anthropogenic zones). Mudflows are fed by numerous anthropogenic landslide and landslide-scree massifs formed by mining activities. Activation and is often associated with subsidence processes, which manifest themselves in the locations of the facilities of the Urup plant.

On the territory of the Kabardino-Balkarian Republic for the period under review, as well as in the KChR, various types of manifestations of hazardous natural processes were observed (Table 3).

Table 3. Mudflows and floods in the territory of the KBR for the period from 2015 to 2022

Adminis dis-trict	Highway	River basin	DNP	Date of manifesta-tion DNP	Consequences of the descent DNP. [Kyul et al., 2021b]
Zolsky	"Kislovodsk – Dolina Narzanov – Dzhilysu-Elbrus"	Malka	Mudflow	05.10.2022	At the 59th kilometer, the road is skidding "Kislovodsk – Dolina Narzanov – Dzhilysu-Elbrus"
Elbrus	"Prohladnyj – Baksan – Elbrus"	Baksan	Mudflow	05.08.2022	There is no damage
Chereksky		Cherek-Bezengiysky	Mudflow	01.08.2021	Skidding of the road to the alpine camp "Bezengi"
Chereksk	"Urvan' – Verhnyaya Balkariya - Ushtulu"		Mudflow	24.07.2019	Mudflow on the road at the 65th kilometer
Urvansky	"Nizhnij CHerek - Staryj CHerek"	New Cherek	Flood	18.06.2019	The road was washed away between the villages of Nizhny and Old Cherek. In the village of Psykod, the bridge over the Novy Cherek River was damaged. Residential buildings and more than 100 hectares of farmland were flooded. The threat of destruction of the dam.
Elbrus	A-158 "Prohladnyj-Azau"	Baksan	Flood	05.07.2018	12 sections of the road were washed away, four bridges and several power transmission towers collapsed. A section of the gas pipeline is damaged
Urvansky	"Nartkala – Ozrek – Staryj Uruh"		Flood	13.01.2017	A section of the road between Nartkala and Old Urukh and a dam on the Cherek River were destroyed
Elbrus	A-158 "Prohladnyj-Azau"	Adylsu, Baksan	Mudflow	01.09.2017	Breakthrough of Lake Bashkara. Destruction of highways. There are human casualties
Chereksky	"Kara-Su – Bezengi"		Mudflow	24.06.2016	Skidding of the road between the villages of Karasu and Bezengi and the homesteads of the village of Karasu
Elbrus	"Baksan-Azau"		Mudflow	25.06.2015	A mudslide in the Suu-kosh tract blocked the road. The volume of mudflows - 100-120 thousand m3
Zolsky		Zolka	Flood	30.05.2015	The villages of Shordakovo and Kichmalka were flooded, 2 bridges were damaged. There are several private households in the flood zone.

In the Cherek Bezengisky gorge in the spring of 2016, during field surveys, mudflows of small and medium volumes were recorded, first of all, the left tributary of the Karasu River near the village of the same name (Figure 4).

(a) **(b)**

Figure 4. The left tributary of the Karasu River without a name near the village of Karasu (photo on the left – March 2016), (photo on the right – after the mudflow descent on 06/24/2016). Photo Gedueva M. M.

Surveys with instrumental measurements show that the mudflow was formed as a result of showers the day before, due to the sliding of the slope along the right bank downstream 1000 m above the village of Karasu. The volume of deposited material is 120,000–150,000 m^3. Mudflows covered household plots, partially destroyed outbuildings. After the mudflow descent, it was planned to build a mudflow flume along this channel.

Also, several sections of the Baksan-Azau highway are periodically covered and washed out by mudflows. Micro-mudflows descend along temporary streams and almost every year and enter the Baksan-Azau federal highway (for example, Figure 5).

(a) **(b)**

Figure 5. Sediments after microflow flows along a temporary watercourse of storm origin above the gas station in the Tegenekli settlement. Photo by Kyul E. V. 2017

On September 1, 2017, a catastrophic mudflow formed along the Adylsu and Baksan rivers as a result of the outburst of Lake Bashkara. The breakthrough was caused by anomalous heavy rains that took place the day before and on the night of August 31 to September 1 in the gorge of the Adylsu River, which eroded the ice-moraine bridge. Up to 1 million m^3 of water was discharged from the lake. The drop in the water level in the lake is 22–25 meters. According to the automatic weather station installed at the Dzhankuat Moscow State University, from August 28 to September 1, 200 mm of precipitation fell, of which more than 100 mm fell after 20:00 on August 31 (the monthly norm in August is about 80 mm). This mudflow can be attributed to a mixed or glacial-storm type.

As a result, 3 sections of the road were destroyed in the Adylsu gorge and on the very territory of the Dzhantugan base, where eight residential premises were demolished - the so-called "barrels" (for example, Figure 6). The mudflow washed away seven sections of the A-158 Prokhladny-Azau road, with a total length of 3.3 km. Four bridges across the Baksan River were destroyed, supports were washed away and gabions of the bridge were cut above the village of Neutrino and near the village of Verkhniy Baksan. Three people died.

Figure 6. Consequences of the breakthrough of the lake and the descent of the mudflow in the gorge of the river Adylsu. Photo by Dzhappuev D. R.

4. Conclusions

Mudflow and flood processes in the territories of the KChR and KBR differ in their characteristics, namely, the conditions of formation, volumes of flows, etc. In contrast to the KBR, in the territory of the KChR, for example, the absolute heights are lower, there is also a greater gentleness of the slopes and their good forest cover, and, secondly, a much smaller scale of modern glaciation of the Kuban basin compared to the Terek basin. It is also important to note that in the mountainous regions of the KBR, outburst glacial lakes pose a great danger, often being an impetus for the formation of a mudflow or flood flow of catastrophic force, while for the territory of the KChR, these processes have a rain, torrential genesis to a greater extent. One of the most mudflow-active regions of the Karachay-Cherkess Republic is the Teberda River basin, including its sources. In the upper reaches of the Teberda there are: the famous resort village of Dombay, the Alibek alpine camp, cable cars and other recreational facilities, some of which are located in the mudflow impact zone. For the territory of the KBR, the most catastrophic and frequent manifestations of hazardous natural processes are recorded in the Baksan river basin.

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