საერთაშორისო სამეცნიერო კონფერენცია „დედამიწასა და მის გარსებში მიმდინარე გეოფიზიკური პროცესები“
შრომები, ISBN 978-9941-36-147-0, თბილისი, საქართველო, 16-17 ნოემბერი, 2023 წ.
International Scientific Conference "Geophysical Processes in the Earth and its Envelopes"
Proceedings, ISBN 978-9941-36-147-0, Tbilisi, Georgia, November 16-17, 2023

REGULARITIES OF MUDFLOWS AND FLOODS FORMATION IN ARMENIA

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Abstract. *The greatest prevalence of mudflows in Armenia is observed in its north-eastern and south-eastern regions, as well as on the south-western and southern slopes of the Aragats and western slopes of the Gegham volcanic massifs. This pattern is related to the lithological composition of rocks, their filtration coefficient, the steepness of the slopes and the degree of their exposure. After 2011, the formation of mudflows in Armenia decreased due to a decrease in precipitation. However, the frequency of repeated floods on rivers flowing through settlements has increased due to the littering of the channels of local watercourses.*

Key Words: *Armenia, mudflow, flood, river bed*

Introduction. Mudflows are one of the formidable natural phenomena that cause enormous damage to anthropogenic objects and are often accompanied by numerous human victims. In the last few years, significant climate changes have been observed everywhere in the world, which is manifested by an increase in the number and frequency of catastrophic mudflows associated with the precipitation of several monthly precipitation norms in a short period of time and, accordingly, with sharp rises in the water level in rivers [1-6]. Destructive mudflows in Tajikistan (April 2014), Kyrgyzstan (late May 2016), Colombia (April 1, 2017) were accompanied by numerous destructions and human victims (*news.rambler.ru/disaster/36502399*). Heavy precipitation in the summer of 2022 provoked landslides and the formation of mudflows in India, Pakistan, Switzerland, Peru, Ecuador, Chile, Georgia (village of Shovi, August 4, 2023) (*www.youtube.com.watch*) and other mountainous regions.

The risk of mudflows is quite high in Armenia, based on the mountainous nature of the relief of the republic, frequent heavy rains (often with hail), active physical weathering of rocks and accumulation of unstable loose material on the slopes as a source of solid component for mudflows.

The timing of mudflows in Armenia to certain areas. The greatest prevalence of mudflows in Armenia is noted in its north-eastern and south-eastern regions (the southern slopes of the Viraayots mountains, the south-western slopes of the Tsakhkunyats and Sevan ridges, the southern slopes of the Bazum, Megrin, Bargushat, spurs of the Zangezur ridges), as well as on the south-western and southern slopes of the Aragats volcanic massif.

According to geological, geomorphological and climatic conditions in the republic, the northern, western, southern and south-eastern mudflow districts are distinguished. Mudflows are most active in the first, second and fourth districts, where poorly permeable rocks (filtration coefficient from less than 5*10-5 to 0.5 m/day) are common within the folded-block ridges: various clays, clay shales, dense sandstones, limestones. On the exposed slopes of the southern exposure (their angle of inclination is in most cases 20-30^0), intensive physical weathering of these rocks and the accumulation of loose material in a rather unstable state occurs. Therefore, with heavy summer rains or stormy snowmelt in the spring, this loose material is easily demolished from the slopes and forms a mudflow component. Mudflows are usually formed on the slopes of the folded-block ridges [7].

The volcanic massifs of Armenia are characterized by the presence of fractured basalts, andesite-basalts, porous tuffs (the filtration coefficient of these rocks is quite high – up to 1 cm/ sec) and relatively more gentle slopes (mostly 10^0). Surface runoff is weak here, so mudflows within volcanic massifs are formed mainly in their summit belt, where a lot of precipitation falls (hail showers are frequent), a powerful snow cover is formed up to

2.5-3 m high, which in some years begins to melt violently, and accumulations of pyroclastic material (volcanic sand, slag, perlite, etc.). Such a mudflow site is the Selav-Mastara – one of the fairly active watercourses of the first category of mudflow hazard with a repeatability of mudflows in 3-10 years on the southern slope of the Aragats massif. In volcanic areas, water-stone mudflows are more often formed [8].

The Getar River originates from the western slope of the Gegham volcanic massif, known for its mudflow activity and especially for the catastrophic mudflow of 1946, which caused significant damage to the Armenian capital Yerevan. A mudflow wave with a height of 4.9 m brought blocks up to 1.5-3.0 m in diameter to Yerevan, and the volume of the mudflow exceeded 1 million m^3. Houses and bridges were destroyed; mud-stone mass flooded gardens and vegetable gardens (see Fig. 1).

Fig. 1. Mudflow of 1946 in Yerevan.

From the mid-90s of the XX century to the first decade of the XXI century in Armenia, according to the Ministry of Emergency Situations of the republic, 142 cases of heavy rains and 380 cases of hail were noted, which caused the formation of 184 cases of mudflows and 193 cases of floods. At the same time, if in the period from 1994 to 2001 the total annual number of mudflows in the republic did not exceed 5 (and in 1996 and 2000 there were no cases of mudflow formation at all), then since 2002 mudflow activity has sharply increased, especially in the Lori and Aragatsotn regions (see Table 1).

Table 1. The number of cases of mudflows in Armenia during the period from 1994 to 2011.

Area	1994-2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	The amount
Ararat	0	0	2	0	0	0	1	1	1	1	0	6
Armavir	1	0	0	1	0	0	0	0	3	0	0	5
Shirak	2	0	5	3	3	3	1	0	2	3	1	23
Aragatsotn	3	0	6	4	3	2	9	0	3	1	1	32
Lori	2	3	6	0	0	1	4	0	13	3	3	35
Tavush	0	1	3	0	0	0	1	0	0	1	1	7
Syunik	3	0	1	0	2	0	0	0	3	4	0	13
Gegharkunik	5	1	5	7	0	0	2	0	1	2	0	23
Vayots Dzor	3	2	1	0	4	1	5	2	2	1	1	22
Kotayk	1	2	0	4	1	0	1	0	1	1	0	11
Yerevan	0	0	0	0	2	1	0	2	2	0	0	7
The amount	20	9	29	19	15	8	24	5	31	17	7	184

After 2011, mudflow activity in the republic began to decline as a result of a decrease in atmospheric precipitation. But floods on the rivers flowing through the settlements have become more frequent. With short-term intense downpours, the water does not fit in the beds of small rivers and floods the streets of settlements. So, in June 2015, heavy rains caused flooding of certain sections of Gyumri: Jivani Street and the temporary parking quarter near the bus station. The local river overflows its banks after every heavy rain. The reason is banal – rainwater does not fit in the riverbed littered with household and construction debris and floods the streets and houses of the city.

In June 2016, 20 houses in Vanadzor were flooded. Again, due to heavy rain, the waters of the local Tandzut River, unable to fit into the littered riverbed, overflowed the banks and flooded the nearby areas with all the buildings.

In June 2016, after heavy rain with hail in the vicinity of the Aragats volcanic massif (50-60 mm of precipitation fell in an hour) and intense snow melting on the slopes of Aragats, large masses of water rushed along the bed of the Garangu River to Artik, where they overflowed their banks and, forming a new channel, flowed right through the streets of the city among houses and vegetable gardens (see Fig. 2 - 3). Why did this become possible? Usually, the water along the Garangu riverbed flows in a thin trickle only in autumn and spring, the rest of the time the riverbed is used by the local population as a garbage dump, illegal vegetable gardens (even chernozem was brought), as well as for the construction of cowsheds and even residential buildings!

Fig. 2. Mudslides of the river Garangu in the Article – June 24, 20

Fig. 3. The site of the city of Artik after the flood peak

In June 2016, powerful streams of water picked up all the garbage, imported soil and brought them down on buildings and vegetable gardens, all livestock was destroyed. According to the Ministry of Emergency Situations of the republic, 120 trucks of stones, mud and silt were removed from the streets of the city of Artik after this mudflow (flood). The thickness of mudflow deposits on the streets of the city was 1.5 m in places. A flood of this force in the Artik is being celebrated for the first time in 200 years.

In July 2009, a flood occurred in Avan (one of the districts of Yerevan). The water stream flowing through the streets of the district had a depth of 30-50 cm. The reason for this situation is the clogged drainage hatches with garbage and the low culvert capacity of pipes. A similar flood occurred in Yerevan on July 14, 2017 (see Fig. 4).

Fig. 4. The situation after a downpour on July 14, 2017 in Malatia (South district of Yerevan).

The author was a witness how on the evening of October 7, 2010, a heavy downpour in Yerevan turned Komitas Avenue into a water stream that occupied the entire roadway and also flooded the sidewalks with a layer of water up to 5 cm thick (shoes were completely covered with water) – the drainage hatches could not cope with a large volume of water, and the water went down the roadway and sidewalks.

A real mudflow formed on the railway stretch of Alaverdi-Akhtala on the night of June 7, 2023 after heavy rains that lasted for several days. Mud-stone soil blocked the railway tracks on a 100m section (*www.panorama.am.news.2023/06/07*) (see Fig. 5).

Fig. 5. Mud-stone mass that blocked the railway tracks on the Alaverdi-Akhtala stretch

Conclusion

The formation of mudflows in Armenia is associated with the lithological composition of rocks, their filtration coefficient, the steepness of the slopes and the degree of their exposure, as well as with intense summer showers or rapid snowmelt in spring. After 2011, the formation of mudflows in Armenia decreased due to a decrease in precipitation. However, the frequency of floods on rivers flowing through settlements has increased due to the littering of the channels of local watercourses, as well as on the streets of cities, since drainage hatches do not have time to absorb large amounts of precipitation due to their clogged with garbage. The problem can be solved as follows: in the case of rivers, by deepening their channels by at least 0.5-1.0 m with preliminary cleaning of the channels from construction and household garbage; in the case of city streets, it is necessary to put drainage hatches in order (to clean them from garbage more often, and also, if possible, replace them with new ones with a large diameter so that they have time to absorb downpour water from the rather steep city streets of Armenia).

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