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Damage and consequences of mudflows in Central Tajikistan

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Abstract. Mudflows are typical not only for most of the mountainous regions of Tajikistan, but also for all regions of Central Asia. When passing, they led to casualties and destruction. This process has been studied since the second half of the 19th century. Significant research experience has been accumulated, especially in the field of identifying the parameters of mudflows and measures to protect against them. In the history of the study of mudflows in Central Tajikistan, two periods can be distinguished - the stage of episodic studies from the middle of the 19th to the middle of the 20th century and the modern stage of systematic studies. A number of summaries works and monographs have been written about the mudflows of Central Tajikistan, and bibliographic summaries have been compiled. The evolution of glaciation and mudflow activity was considered in the book by I.B. Seinova and E.A. Zolotarev (2001).

Keywords. Mudflow basin, flow, rescuers of the CoES, mudflow masses, deposition, generation, transit, accumulation, lithodynamic criterion.

1. Basic concepts and terms

Under mudflows foci are called stormy mud or mud-stone flows, which suddenly appear mainly in the channels of mountain rivers as a result of a sharp flood caused by intense downpours or intense snowmelt in conditions of accumulation of a large amount of weathering products on the slopes (Shukin, 1980). In the English-language literature there is no single concept analogous to the word "mudflow". The terms “mudflow” (mud mudflow) and “debris flow” (mud-stone or alluvial mudflow) and the related concept “debris avalanche” (mud-stone avalanche) are used. There are various definitions for the concept of “mudflow source” [1, 2].

Mudflow sources are understood as all areas that supply solid material to the mudflow or can serve as a source of food in the future, located both in the generation zone and downstream. Both the foci of mudflows and the foci of solid nutrition are called for brevity by the single name “mudflow center” [5].

Mudflow basins are basins in which mudflows are formed or may be formed. Difficulties often arise when using the concept of "mudflow basin". It is necessary to indicate by what criterion its boundaries are distinguished: the catchment area of the mudflow source; a catchment basin of a given order; The catchment area of closing gates, at which the mudflow turns into a nanoflood [2-5].

It is possible, apparently, to speak of three prevailing types of mud flow systems in the central part of the Republic of Tatarstan: isolated and open sources predominate in the surveyed reservoirs, and traces of the mudflow regime can be found in most river valleys. The central part of the Republic [5].

Mudflows lead to a change in the relief, as a result of which, in many cases, an increase in avalanche danger is observed due to the formation of new avalanche collections. The vegetation cover of the slopes is greatly influenced by mudflows and landslides, which eliminate the vegetation cover in avalanche areas [6].

Ultimately, the action of the processes under study leads to an increase in georisk, primarily for the mountain population and household facilities, which makes it difficult to protect and design engineering structures. Mudflows cause great damage during periods of massive mudflow formation, primarily caused by heavy precipitation when they reach a wide part of the hollows.

To prevent mudflow danger, it is necessary to create a network of observation stations for mudflow processes and phenomena, daily visual inspection of the slopes adjacent to the settlement [6.8].

In order to identify patterns of distribution and development of mudflow processes in the Zeravshan river basin and to develop measures to prevent and reduce georisks, we conducted a survey. The studies were carried out using engineering-geological and engineering-geonomic methods of analytical, cartographic, expeditionary, field work and visual field observations [7].

The results of the dissertation work are recommended for use in updating the Atlas of Natural Hazards of the Republic of Tajikistan, the Landslide and Mudflow Hazard Inventories and were requested by the Committee for Emergency Situations and Civil Defense of the Republic of Tajikistan when developing measures to prevent emergency situations, when developing recommendations for the prevention of georisks in order to reduce the level of vulnerability of the components of natural environment to dangerous exogeodynamic processes, when carrying out cost-effective environmental protection measures.

The results of the work in the form of recommendations were introduced into the practice of the Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan (act of implementation dated February 6, 2019); an act was received on the implementation into practice of the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan dated December 14, 2019 [9].

By geographic location, Central Tajikistan occupies an intermediate position: both isolated foci and their systems are found here. It is known that in the mudflow basin there are zones of origin, transit and accumulation of mudflow material. However, the criteria for division into zones and the analysis of their combinations in different basins have not yet been the subject of consideration. As a quantitative parameter for delimiting zones, one can use the lithodynamic criterion - the value of the balance of sediments in the channel section [10].

Three types of indicators should be distinguished, called the volume of debris flow:

- the total volume of material involved in the flow (∑Wtotal),
- the total volume of the solid phase of the material involved in the flow (∑W),
- the volume of the solid phase that passed through the given section (channel section) during the entire mudflow (W).

The volume that passed through the target during the entire mudflow (W, m3) is an auxiliary parameter necessary for further calculations of the total volume of the mass involved in the flow [10-11].

The total volume of the solid phase of sediments involved in the flow (∑W), as a rule, can be determined by field measurements after mudflows in various sections.

The indicators ∑Wtot and ∑W are related by the relation: ∑Wtot = ∑W/α, where

α - is the share of rock in mudflow mass.

In the general case, the total volume ∑W, m3 is: $\sum W = \iint dB \cdot dH \cdot dL$, where

L - length,

B - the width of the plot,

H -is the thickness of mudflow deposits [1, 3].

The volume of sediments in the alignment does not serve as its exhaustive characteristic. Let's denote two relations:

W' = dW/dL - volume increment along the length and

W'/W is its specific increment.

The volume increment along the length W' characterizes the intensity of the denudation-accumulation process. The specific volume increment along the length can be written as:

W'/W = dW/WdL [2].

Depending on the budget of the mudflow mass, the channel can be divided into lithodynamic zones:

predominantly denudation (D),

transit-denudation (TD),

predominantly transit (T),

transit-accumulative (TA) and

predominantly accumulative (A).

The criterion for delimitation of lithodynamic zones is a sharp change in the increase in volume along the length of the riverbed W'. The ratio of zones is a kind of geomorphological "passport" of the basin [2, 4]. The concept of "catastrophic mudflow" has not yet been enshrined in regulatory documents. Catastrophic mudflows in Central Tajikistan include flows with a volume of at least 1 million m^3, accompanied by economic damage or loss of life [4-12].

Since experience shows that disasters occur repeatedly in the same basins, it is important to formulate provisions on the main stages of the development of a catastrophic process in the form of a concept of a special “cycle of catastrophic mudflow formation”.

The cycle of catastrophic mudflow formation is a period that includes the preparation of a catastrophe and loss of stability, the action of a “trigger mechanism”, the catastrophic development of a mudflow process, subsequent post-catastrophic processing, and a relatively calm long period of evolutionary development that occurs without loss of stability of the geomorphological system.

The conducted studies show that the cycle consists of a number of stages, which can be called the following terms:

1) the stage of pre-catastrophic preparation,

2) stage of mudflow disaster,

3) the stage of epicatastrophic adaptation (from the Greek epi - on, over, over, with, after),

4) the stage of between catastrophic evolution [2].

In a prepared basin, a catastrophic development of events occurs after a small process, which is the initial impulse of the catastrophe. The ratio of the total volume of a catastrophic mudflow to the volume of the material that caused the initial impulse is called by us the coefficient of multiplicativity of a mudflow disaster [11-13].

This indicator serves as a characteristic of the transformation of matter during a catastrophic process. To assess the magnitude of denudation carried out by mudflows, it is necessary to introduce a special indicator. Integral mudflow activity I is the value of the average conditional layer of matter displaced by mudflows per unit time (mm/year):

$I = \int W_{full} \cdot 103 / (F \cdot T)$, where

∫Wtot is the total volume of debris flows for the period under review, million m^3,

F- is the area of the territory, km^2,

T - is time, years.

The re-engagement of part of the sediments of previous mudflows into new flows can be called “mudflow mass regeneration” It is advisable to introduce a special parameter - the mudflow mass regeneration coefficient, which is the proportion of the solid phase of mudflow material re-engaged in the mudflow process by a new mudflow, in the volume of the solid phase of this new mudflow [4].

2. The knowledge of mudflows

Catastrophic mudflows are typical for most of the mountainous regions of Tajikistan, mastered by man. When passing, they led to casualties and destruction. According to the Ministry of Emergency Situations of the Republic of Tajikistan, from 1997 to 2005, strong mudflows occurred in the central part of the republic and in the Sughd region in Aini, Asht, Ura-Tyube, Penjikent, Isfara, Zafarabad districts and other regions [15-16].

Mudflows in Central Tajikistan have been studied since the second half of the 19th century. Significant research experience has been accumulated, especially in the field of identifying the parameters of mudflows and measures to protect against them.

In the history of the study of mudflows in Central Tajikistan, two periods can be distinguished - the stage of episodic studies from the middle of the 19th to the middle of the 20th century and the modern stage of systematic studies [3].

A number of summaries works and monographs have been written about the mudflows of Central Tajikistan, and bibliographic summaries have been compiled. The evolution of glaciation and mudflow activity was considered in the book by I.B. Seinova and E.A. Zolotarev (2001).

Mudflows passing through the Zeravshan Valley

The most catastrophic passage of mudflows was noted in 2021. In July 2021, as a result of past heavy rains, mudflows descended on the territory of four districts of the Sughd region [15].

Torrential rains caused mudflows in the village of Dashti Kozi of the Yori rural jamoat of the city of Penjikent, Sughd region.

According to the CoES, as a result of the disaster, the mud-stone mass partially damaged 15 residential buildings, household plots, damaged 3 km of the inter-settlement road, 35 heads of cattle and small livestock fell. The local population, at approximately 5:30 pm local time, removed the bodies of two women from under the mud mass [11-12].

On the summer pasture of the village of Kishtudak, located at an altitude of about 30 km from the rural jamoat Dashti Kozi, 10 people grazing livestock were hit by mudflows. To carry out search and rescue activities, rescuers of the CoES in the Zeravshan zone of districts were immediately sent to the scene.

After carrying out rescue operations, the bodies of 8 residents of the village of Kishtudak were removed from under the mud masses [11].

Mudflows were also recorded in the territory of the village of Vashan, Urmetan rural jamoat, Ayni district. According to preliminary data, as a result of mudflows, 4 km of a country road, 2 bridges, power lines, mudflows were damaged, basements of 8 residential buildings and household plots were partially filled with mud and stone mass. There are no victims.

On the same day, as a result of intense rains in the villages of Pastigav, Khadishahr, Tit, Rogif and Revemutk of the Ivan-tochik rural jamoat of the Gorno-Matcha district of the Sughd region, mudflows were also recorded. As a result of the disaster, 3 residential buildings were completely damaged, 5 residential buildings, 8 auxiliary structures, 10 km of a highway, 20 hectares of arable land, and 2 bridges were partially damaged. There are no victims [16].

On July 19, 2021, at 17:30 in the village of Rosrovut of the rural jamoat of Rosrovut and in the village of Nekti of the rural jamoat of Vahdat of the Devashtich district, mudflows were recorded, as a result of which 15 residential buildings, country roads and household plots were partially damaged [8]. In other regions of the republic, spring precipitation with mudflows was also observed.

3. Conclusion

The process of precipitation and mudflows occur annually and causes great damage to the economy of the Republic. In the mountainous and foothill areas, there is a change in the terrain, in many cases there is an increase in avalanche danger due to the formation of new avalanche collections. On the slopes, the influence of mudflows is great, that the process of passage leads to erosion of the fertile soil and landslides. In recent years, this process occurs not only in spring, but also significantly in summer. The given examples of passage of mudflows along the Zeravshan valley indicate that the climate is changing and it is necessary to be prepared for a natural cataclysm.

Conflicts of interest：The authors declare no conflicts of interest regarding the publication of this paper.

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