

Engineering investigations as a basis of ecologically safe construction in the conditions of highlands

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Abstract. Article is devoted to separate problems of carrying out engineering investigations under construction of mountain and sports complexes in mountain conditions. Conditions of highlands define extremely high dynamics of all processes, both dangerous engineering-geological and geochemical, which causes problems when carrying out engineering-geological and engineering-ecological investigations, so we are going to discuss them in this article. Specifics of the engineering-ecological investigations organization of are connected with lack of normative indicators for the main components of mountain landscapes - hard bed rocks. The specifics involve difficulties of their realization due to dangerous geological processes in mountain conditions on one hand, and lack of representative ranks of their monitoring observations on the other hand, which interpretation is necessary for their forecast. Authors offer solutions of the above problems on the example of the carried-out engineering investigations.

1. Introduction

Engineering investigations are basis of environmental safety of construction and therefore it is the obligatory type of works, preceding its zero cycle. Besides, it is, in fact, scientific and technical maintenance of construction, especially when it is carried out in difficult conditions, such as highlands.

The Engineering Investigations (EI) in mountain conditions are usually carried out for construction of mountain and sports complexes intended for skiing, bobsleigh, etc. At the same time IR performers have problems of the organizational plan, as development of mountain territories is a quite complicated task, as you need to provide both ensuring environmental safety of functioning of the mountain and sports complexes (MSC) and assessment of reliability of constructions.

Problems, methods, and stages of carrying out IR are written in detailed rules of the normative documents, and in this article authors tell only features of some types of works and their technologies in mountain conditions, giving specific examples and results of their own investigations..

2. Literature review

It is known, that mountain territories are characterized by the low power of friable deposits, and as a result hard bed rocks are located on a day surface and the area of their exits quite often exceeds the



areas of friable deposits of various genesis. Soils are developed not everywhere and their soil profile is, as a rule, shortened.

Thus, when engineering-ecological investigations take place, performers are forced to estimate bed rocks according to the geochemical indicators. But in the existing normative documents there is no estimation scale for bed rocks [1]. There are documents for rationing of soils, superficial and groundwater, etc. The question with rationing of bed rocks, and, therefore, and with assessment of suitability of use of territories for construction in the conditions of highlands is still opened.

During the engineering-ecological investigations, it is necessary to consider the possible increased contents of toxic elements in bed rocks. These elements can be source of their accumulation in the depositing landscape components. There are considerable reserves of ores are concentrated in mountains. Ore elements are often toxic. For example, as a part of polymetallic fields the basic ore elements are lead and zinc, and their attendants are cadmium, mercury and arsenic. All these toxic elements belong to 1-2 classes of danger. And their form, as a rule, is sulphidic. During the oxidation process from sulfides to sulfates, the acid medium is formed, which considerably increases migratory abilities of the majority of heavy metals [2]. That's why during the engineering-ecological investigations in mountain territories it is necessary to consider potential natural ekologo-geochemical danger, which is caused by geochemical background of the territory. And the geochemical background of the area is defined by originality of chemical composition of bed rocks [3].

The second feature of engineering investigations discovers exactly engineering-geological investigations. It involves special studying of the dangerous geological processes (DGP), as highlands cause the high frequency and intensity of their manifestations, sometimes with catastrophic consequences.

3. Materials and methods

Authors offer to consider their experience of estimation of similar territories on the example of the carried-out ER under their management in the valley rr. Mamisondon and Adayky, Northern Ossetia-RNO. Alania under construction of MSC «Mamison» which was projected as reserve object for holding the winter Olympic Games in Sochi in 2014. Absolute marks of the studied MSC hesitate from 2200 to 3400 m.

The technology of studying of the dangerous geological phenomena during the engineering-geological investigations also had its own features at all stages of works: from propedeutic to cameral stage of processing of field work materials.

The central goals were drawing up maps of preliminary approbation, taking into account the available information (the geological map, the landscape map, the map of geological complexes, etc.) – for engineering-ecological investigations and drawing up the preliminary map of quarternary deposits according to the deciphering results –

During the preliminary stage, on the basis of of remote sensing data and stereo deciphering aero – and space images (AFI and SI), the preliminary schematic map of quarternary deposits of scale 1:50 000 was made with the help of special tools. Specifics of its drawing was that the main genetic types of dangerous processes on their net result – formation of the corresponding accumulation in modern relief were preventively allocated. Besides, degree of their estimated activity on the shown morphological and other features, and also on degree of dissection of modern relief and many other signs were analyzed. For example, for assessment of engineering geodynamic status of mudstone qualitative assessment of territory was made on degree of modern erosive dissection of basins of valleys – drainage basin inflows of river Mamisondon and Adaykomdon.

Then, according to results of land routes the final map of quarternary deposits was made.

Carrying out approbation of the main components of landscape, their delineation and the description – for engineering-ecological investigations were problems of the field period. For engineering-geological – inspection of mudflow and landslide, mapping of manifestations of exogenic geological processes and identification of the reasons of their emergence.

Having the retrospective geological map, the map of preliminary approbation, the corresponding scales, and also preliminary map of quaternary deposits 1:50 000 scales, technology of field work generally comes down to geochemical approbation of all components of geologic environment – bed rocks, soils, ground deposits, superficial and groundwater and to route descriptions of the area.

Approbation on point was followed by the description of geomorphological, geological, hydrogeological situation on the approbation platform, and also existence, character and degree of manifestation of signs of change of NGS natural, or anthropogenic processes.

Within the studied object, profiles of sampling of radical deposits were planned, so that to characterize each geological division (formation, complex, etc.).

Approbation of bed rocks was carried out for definition of geochemical specialization of geological divisions (complexes) and for identification of their role in formation of natural geochemical danger and their influence on the deposited components of landscape [5].

The main types of rock formation which are coming to day surface or having low-power (0-0,2m) the easily washed away covering deposits were subject to approbation.

Ground deposits and soils were tested for each valley separately, that is each valley was characterized by several tests in upper course, average current and in lower. Tests of the soil were selected from each type of soils.

At engineering-geological investigations during the field period it was established that on structure of the displaced masses landslides, are generally subdivided into 2 types: diluvial, structurally-gravitational. Besides, the fact, so-called, hydrogene desorption were noted.

4. Results

During the field observations it was recorded that diluvial landslides, generally consist of the loam including large amount of crushed stone from small to large. They have no wide circulation on the area and represent the isolated landslide bodies.

Structural and gravitational landslides have other structure. In their structure, except friable deluvial deposits, blocks of the bed rocks displaced downhill together with slide-rocks and sometimes shattered into blocks of the different sizes take part.

In accordance with results of on-site investigations part of landslides are carried on age to Upper Quaternary sediments, and on stage of their development – to calmed down, i.e. motions of which are unknown. These landslides have appearance of the ancient completely calmed down educations, the so-called stabilized landslides [1].

Among dangerous geological processes around carrying out investigations mudflows have wide circulation. Among their deposits there were mapped numerous old and hot scents of mudflows which demonstrate their repeated and often inherited manifestation in the territory of investigations.

Distribution of mudflows considerably depends on relief. The lower part of the area of investigations as relief belongs to type mountainous erosive tectonic, and upper – to relief of zones of the early Alpine folding mountainous glacial tectonic.

As a result of inspection of the territory and mapping of basins of the rivers Adaykomdon, Mamisonon, it was classified according to the degree of mudflow danger to an average degree since here mudflows with one-time carrying out of solid material less than 50 000 m³ are shown. Sharply mudflows of mud-stone type with carrying out of solid material from 1000 to 10000 m³ prevail.

Woks of the cameral period consisted in processing of natural investigations, the analysis of tests, database compilation and creation of the corresponding maps. Fragment of one of them – maps of mudflows are submitted in Figure 1.

Holocene mudflows existing and estimated modern mudflows are mapped out (arrows, solid and dashed respectively), the isohyets put with fat isolines and showing distribution of rainfall (mm) for the mudflow period according to mean annual data are displayed. In the same place types of the mudstone centers which are subdivided on genesis into the centers erosive and the mixed type are given. In total territory of investigations is differentiated on two zones on rainfall amount in year according to mean annual data. The most part of the territory is characterized by annual average

rainfall amount from 800 to 1000 mm/year and 125-225 mm/year for the mudflow period, the smaller part located in the valley of river Mamisondon – rainfall amount from 600 to 1000 mm/year and less than 125 mm/year for the mudflow period. The part of the territory characterizing by large amount of rainfall in year and for the mudflow period, in fact, is potentially mudflow.

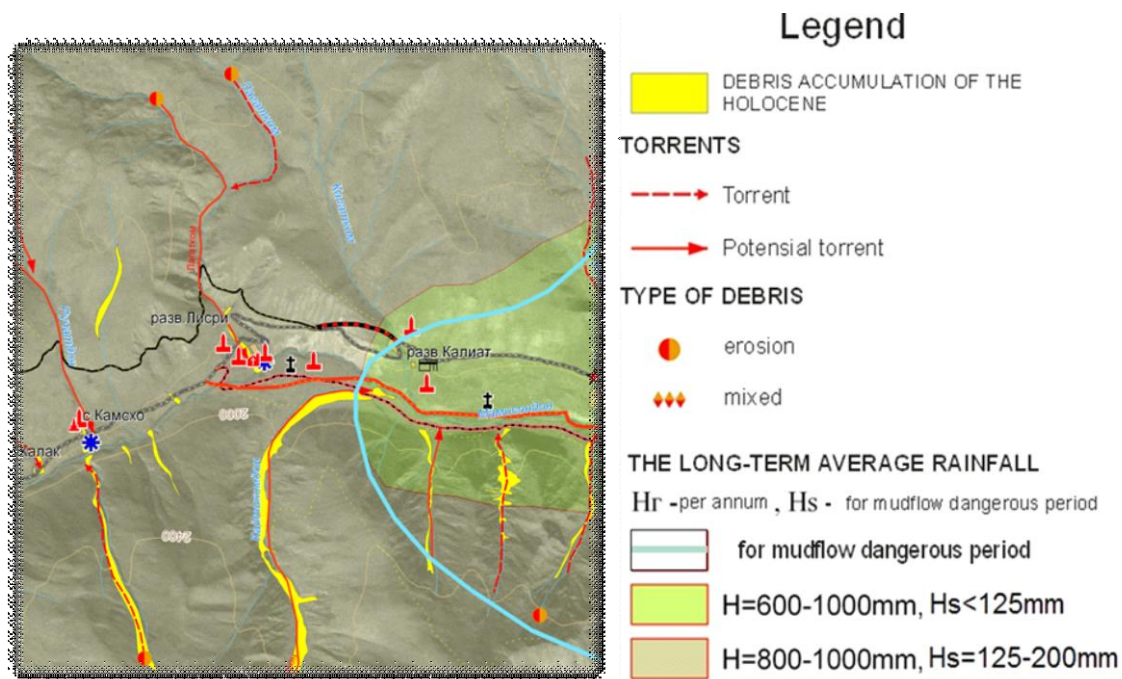


Figure 1.1 The map of floods. Scale 1: 25 000

Thus, the map, considering its high informational content, can be considered as the forecast map of mudflow danger of the area of construction.

Also other maps were constructed: development of landslides, collapses, avalanches and other dangerous geological and meteorological processes. All these maps, and also geomorphological which was mentioned above, were constructed in 1: 25 000 scale. The fragment of the landslides map is presented in Figure 2.

When processing materials of engineering-ecological investigations multi-scale thematic maps, including the map of natural ekologo-geochemical danger were created.

5. Discussion

Thus, on the basis of field observations and their processing it was established, regarding engineering-geological investigations: that activation of dangerous exogenic processes is connected with increase in scales corresponding (on age and genesis) deposits in the course of formation of erosion pattern and decrease basis of erosion in the Holocene. Besides, it was established that activation of the majority of dangerous geological processes is connected with neotectonic motions. Modern tectonic movements on the area of investigations within the Narsky zone of Zaramagsky district are most developed.

River valleys of the drainage basin of the main water currents are deeply cut into slopes of the North Caucasian ridges (Side and Main). In upper parts they keep trough form and have difficult complex of glacial, slope and alluvial deposits. All these deposits, as a rule, friable incoherent breeds and, under certain conditions, can serve as material for formation of mudflows and landslides.

In the described territory mudstone and landslide processes are most developed, both other geological processes and the phenomena, for example desorption are noted. For the first time desorption is allocated as independent genetic type by B V Ryzhov in 1966, its synonym in foreign

literature is, partly, the concept «krip». Conditions of highlands predetermine its formation as there are dry crushed-clumpy flows and slopes which are displaced down slopes with angle 15-25° and more.

In the territory of investigations during the periods of loss of rains also the hydrogen desorption becomes more active. Mechanism of its formation presumably following: the filtrational drain on contact of friable breeds with the rocky basis therefore additional dangerous geological process – mechanical suffosion develops forms and there is carrying out and removal of fine rock particles. The intensification of rains forms separate areas on the slopes, within which the filtration flows are concentrated [7]. So there is a crowding flooding of these areas. And enough even insignificant loadings we will also carry out transition of water-saturated volumes of breed to the movement for the account of sliding. There is reduction of friction forces and coupling that is also the mechanism of formation of landslides of various types – up to liquid (mud-stream). And, it is necessary to emphasize, that landslide process develops in parallel with suffosion [8, 9].

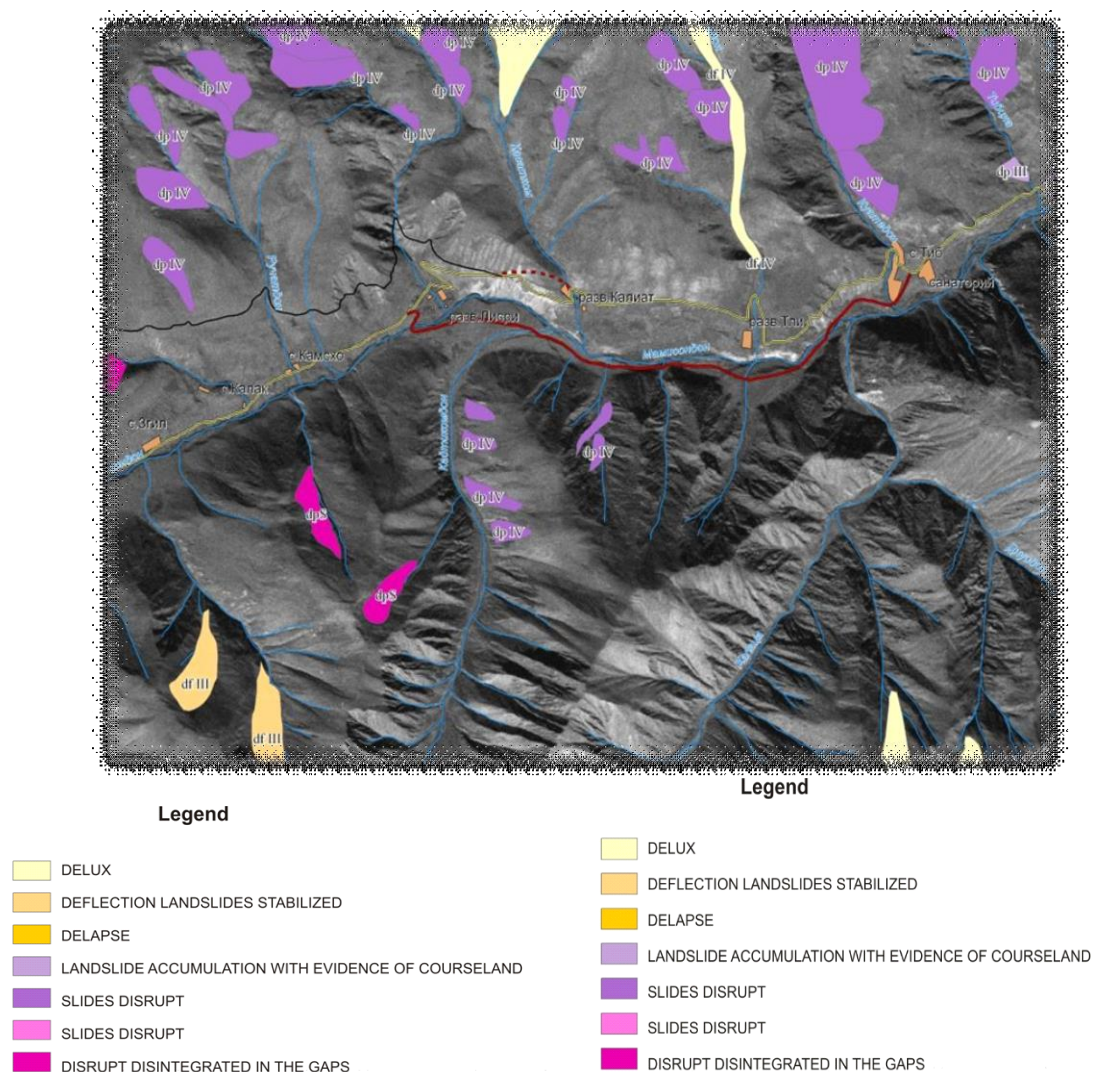


Figure 2. The map of landslides. Scale 1: 25 000

6. Conclusions

Formation of landslides, except the described above mechanism, is promoted by wide circulation of clay rocks of the Jurassic system and their periodic considerable overdamping. It should be noted, that

in interfluvium of river Mamisondon and Adaykomdon the showers are quite often observed, creating floods and promoting overdamping of slopes of valleys. Also important role is played by neotectonic factor. The latest tectonic movements constantly happen on the inherited breaks, renewing them and increasing dissociation of breeds on the weakened zones.

The mudflows map analysis shows, that all drainage basin of the main inflows can be potentially considered – mudflow even if traces of passing of mudflows in them were not observed. Most of them are on absolute marks 2500 – 3000 m, and it is in the Caucasus - the line of the Alpine and subnival belts – heights of the centers of origin of mudflows. Besides, it is known, that downpours play pushing role for emergence of mudflows. For this purpose, the sum of liquid rainfall has to reach the critical size, which fluctuates over a wide range – from 20-30 to 50-70 mm/day. As additional condition of critical mudstone drain formation serves the indicator of intensity of rains (mm/hour), which value also carries regional, and sometimes local character. This indicator reflects specifics of natural settings of the specific area, including morphometry and morphology of mudstone basin. It is established, that the number of cases of mudflows formation from other reasons (thawing of snow, glaciers) is insignificant.

The inspection of mudflow dangerous areas established that in the territory of investigations mudflows of mud-stone and water-stone type, with carrying out of solid material from 1000 to 10000 m³ are most developed.

Material for firm component of mudflows of water-stone type is moraines and fluvioglacial deposits, mud-stone – taluses and landslide deposits.

The most active mudstone basins of the area of investigations are Tsargasta I and Tsargasta II, giving mass transport of mudstone annually. The center of their origin is the body huge landslide, located in upper courses of the rivers of the same name. Big destructions in the area make the disastrous floods of the rivers caused by intensive heavy rains and passing mudflows in upper parts of valleys of the rivers.

Also around investigations micromudflows and mud-stream, with transportation of solid material less than 1000 m³ have wide circulation.

By results of assessment of condition of mudstone reservoirs it was established, that degree of mudflows dangers of the territory of basins of the rivers Adaykom and Mamisondon can be carried to average as here mudflows with one-time carrying out of solid material less than 50 000 m³ are shown.

Results of investigations were used for identification of sites of intensive manifestation of DGP, which constructing facilities recreation actions for their engineering protection will be required.

Coming to engineering-ecological investigations, it is necessary to emphasize, that their feature is quantitative assessment of natural ekologo-geochemical danger (NEGD) of components of landscape. The indicator of potential ecological danger is offered [10, 11].

This indicator is calculated by the following formula:

$$NEGD = \sum Cc - (n-1), \quad (1)$$

where Cc – clarke of concentration of toxic elements, n – number of chemical elements in selection with $Cc > 1,5$ ($Cc = Bc/C$).

Bc – the background content of chemical elements of 1-3 classes of danger, C – clarke of soils of the World (for soils and ground deposits). And for bed rocks – clarke of breeds of the corresponding structure according to Bowen [12].

When processing materials ER by authors of Cc undertook more than 2 since tests were analyzed by method of spectral semi-quantification, which accuracy, as we know, is low. And investigations of A P Vinogradov [13] established that at levels of accumulation is 2 – 3 times higher than clarke serious diseases of people, animals and plants are already observed.

Gradation on NEGD was chosen according to the Sanitary and epidemiologic rules and standards [14]. After development of the natural ekologo-geochemical danger map, depending on size NEGD,

the areas were carried to territories with moderately dangerous (8-16), dangerous (16-32) or extremely dangerous (> 32) the danger levels; it was in addition entered admissible level (< 8) [5].

Thus, at the organization of engineering investigations under construction in mountain conditions, it is necessary to consider their main features, which consist in the following: for engineering investigations they consist in detailed research of manifestations of DGP at all stages of investigations, and for engineering-ecological – in assessment of ekologo-geochemical natural danger of components of landscape of the territory of investigations.

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