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CLASSIFICATION OF LANDSLIDE PROCESS, DYNAMICS OF OCCURRENCE AND CONTROL MEASURES (A CASE STUDY OF CHARVAK FREE TOURIST ZONE)

Abstract: *In recent years, the construction of new hotel complexes, cultural, recreational and shopping centres has been extensively carried out in Charvak free tourist zone, along with other economic activities, with a view to developing the tourism sector. Such construction work could provoke further landslide development on mountain slopes. This article describes in detail the classification, dynamics of landslide processes, one of the most frequently observed in Charvak free tourist zone, and measures to combat them.*
Keywords: *landslide process, factors, dynamics, classification, measure, mountain slopes, groundwater, faults, rock porosity, loess and loess-like rocks, consequent, insequent.*

Introduction. Ensuring the safety of citizens has always been one of the priorities of the state. In this regard, the Government of our Republic adopts resolutions and decrees aimed at ensuring the safety of the population, develops and implements into practice special programs, instructions aimed at their implementation.

Section 7 of the Development Strategy of New Uzbekistan for 2022-2026, entitled "Strengthening the security and defense capability of the country, conducting an open, pragmatic and active foreign policy", consisting of seven priority areas developed on the principle of "From action strategy to development strategy", approved by the Decree of the President of the Republic of Uzbekistan dated January 28, 2022 No PF-60 "On the Development Strategy of New Uzbekistan", a systematisation of measures to ensure the safety of the population and to prevent and deal with emergencies in tourist areas in an expeditious manner is outlined [1]. In this development strategy, the main goals are the protection of the population and territories from dangerous processes that cause emergencies of a natural, man-made and environmental nature.

In this regard, scientific research to reduce the risk of landslide processes is of relevance. From a scientific and practical point of view, it is important to study the classification, grouping and dynamics of the landslide process depending on the factors that form it.

The purpose and objectives of the study. The purpose of the study is to investigate widespread landslide processes, the dynamics of the types and control measures in the Charvak free tourist zone. The following objectives are set in order to achieve the purpose: 1) classification of landslide processes; 2) study of the dynamics of the appearance of landslide processes; 3) study of measures to combat landslide processes and reduce their damage.

The main part. The geological structure of Charvak free tourist zone is composed of limestone, sandstone, shale of different periods, gravel-clay sediments of the Paleogene and Neogene periods. The surface of these layers is covered by thick loess and loess-like rocks, rapidly losing their strength and swelling under the influence of atmospheric precipitation, strongly dissected by earthquakes of the Lower (Q_1) and Middle (Q_2) Quaternary period [4, 9]. For this reason, landslide processes are more common in this area than elsewhere in Uzbekistan.

A landslide is the process of rock falling from the shores of seas, lakes and rivers, or from mountainsides under its own weight down a certain surface on a slope. This process occurs because the rocks on the slope lose their equilibrium state due to various factors [3].

Landslides vary in the size of the area occupied, structure, causes of formation, developmental conditions, mechanism and dynamics. That's why they have different classifications. When classifying landslides, the causes of their formation, properties, shape, size and many other signs are taken into account.

A.P. Pavlov divided landslides into *delapsing* and *detrusion* landslides depending on where the landslide starts. N.V. Rodionov, divided landslides into three types depending on the causes of their formation, these are *consistent, suffosion* and *structural* landslides [2; p. 168].

F.P.Savarensky divided landslides into *asequent, consequent* and *insequent* landslides, depending on the location of the surface of rupture relative to the bedding line [2; p. 168].

Asequent landslides are landslides that occur on slopes consisting of rocks of a homogeneous composition. These include slides on a slope consisting of loess-like rocks. In this case, the slickenside is most often arch-shaped.

Consequent landslides are formed by the sliding of layers formed by weathered rocks over the bedrock (Figure 1).

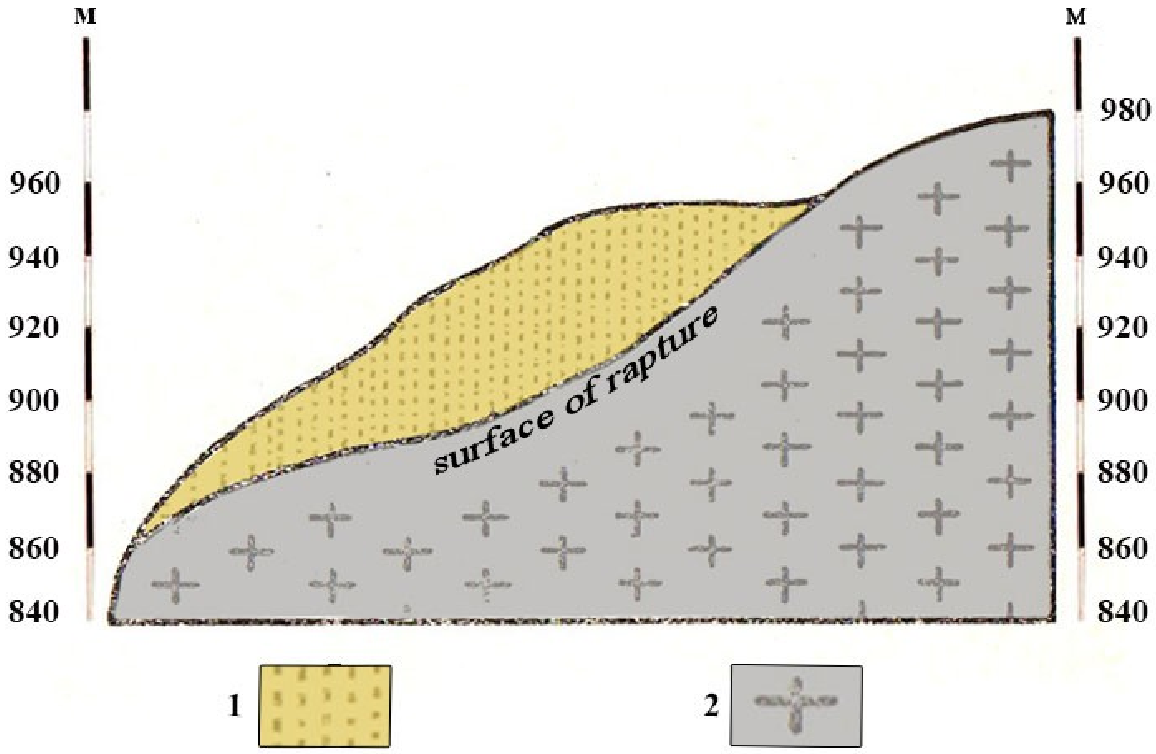

Figure 1. Scheme of a consequent landslide. 1-loess and loess-like rocks; 2-bedrock, consisting of sand and gravel;

Insequent landslides are types whose surface of rupture crosses the bedding line of the rock strata. An example of this is stepped landslides (*Figure 2*).

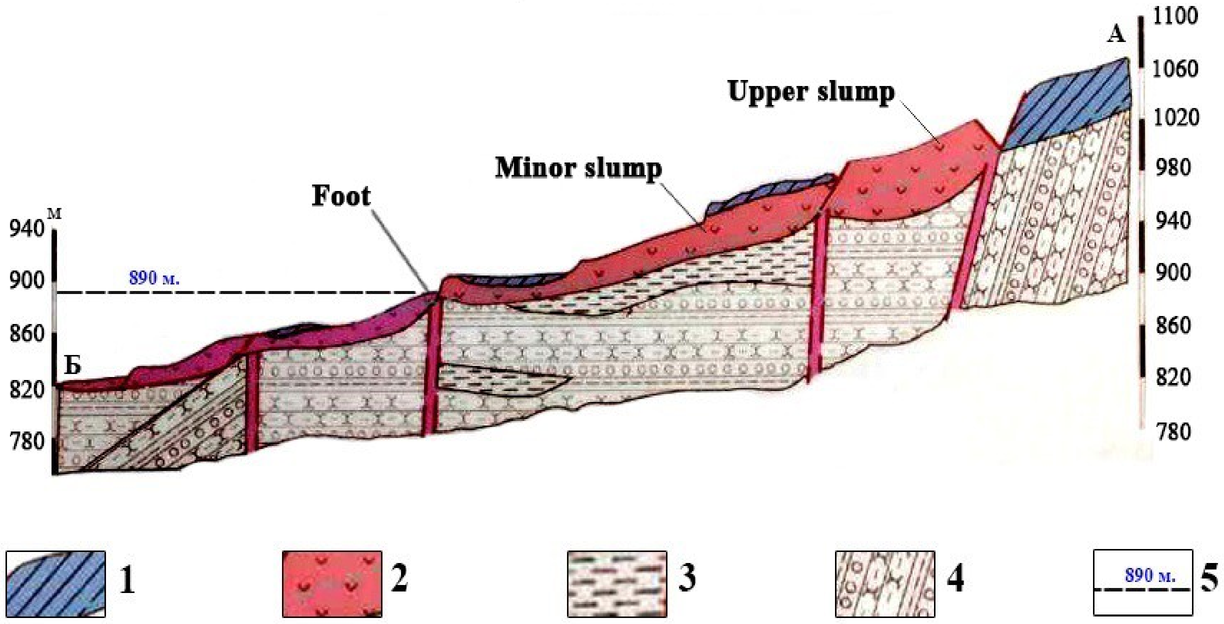

Figure 2. **Longitudinal geological profile of an insequent landslide in Mingchukursai.** 1 - slumped clay rocks; 2 - loess and clay rocks; 3 - groundwater; 4 - the Quaternary conglomerates; 5 - maximum level of water table rise.

In addition, several types of landslides have been identified by A.M.Drannikov, N.N.Maslov, E.P.Emelyanova, G.O.Mavlonov, Niyazov and others. The reason for the diversity of the classification of landslides is the diversity of conditions, causes and structure of their formation.

The *dynamics of landslide processes* is understood as the change in their structure and properties, as well as the speed of movement per unit time from the beginning, through to the passing and stopping stages of development. The action of factors causing landslides on slopes is not always the same, but varies in character and magnitude per unit time. Accordingly, the rate of sliding of rocks on the slopes varies[3, 8]. Based on this, the period of landslide processes can be divided into the following three stages:

1. The stage of preparation for a slumping;
2. Slumping stage;
3. The stage after a slumping occurs.

In the preparatory stage, under the influence of natural phenomena (earthquakes, precipitation, etc.) and human activity, the degree of slope strength decreases, but no slumping has yet occurred, only the first signs of a landslide begin to appear. At this stage, cracks form in the part of the slope where there is a possibility of a slumping.

At the slumping stage, a landslide occurs. The speed of the landslide will not be the same. It can often go fast at first and then slow or vice versa.

The landslide speed occurring at our research site is higher than anywhere else in Uzbekistan, reaching several metres per second. In particular, flowing and sliding types of landslides caused by precipitation move much faster at this stage. Therefore, in the second stage of a slumping, unpleasant events occur, leading to the destruction of economic objects and sometimes to the deaths of people.

At this stage, landslides can also continue for an extended period of time, with temporary halts. This is because the factors causing landslides change their impact from time to time [3]. An example is a sharp reduction in precipitation by summer or a decrease in the water table in early autumn.

The stage after a slumping occurs. After slumping occurs, the strength of the slope changes completely. If the factors eroding the landslide mass are not - flowing water, the degree of slope strength will increase. The slumped mass will serve as a support for the slope. In most cases, as a result of a slumping, the slope slope decreases, and the degree of its strength increases. Sometimes it is the other way round [3].

Due to the landslide, the slope of the slope increases, a head scarp is formed in its upper part, the height of which in the vertical position reaches from 3-4 to 10-15 meters. Cracks then form around and over the head scarp, and new landslides or rockfalls may soon occur along the new cracks.

At this stage, new factors appear that change the strength of the slope. If a landslide occurs in the surface layer of 30-40 cm, then the vegetation covering the slopes will be washed away and its surface part will be exposed. As a result, erosion processes on such slopes increase, leading to increased washout of the subsoil layer.

The occurrence of a landslide process has a major impact on the relief and the mechanical composition of the subsoil layer. For example, if the slumping mass is very thick, landslide cirques (troughs) are formed in its place. Landslide steps form table plains of varying sizes on the slopes. The formation of these table forms changes the geomorphological structure of the slope.

In large landslides, such as stepped landslides, where sandy, sandy-gravel rocks in combination with loess-like rocks or clays are present in the slumping layers, they will mix with each other due to landslides. The result is a change in their specific gravity, volume and degree of porosity. When highly porous rocks are slumped, their porosity decreases, or vice versa [3].

The landslide process that has occurred in some cases alters not only the geomorphological structure of the slopes but also, more frequently, the hydro-geological conditions. If the surface of rupture crosses aquifers, the groundwater regime may be changed. This shifts the aquifers and changes their structure and occurrence forms. As a result, groundwater comes to the surface, forming springlets and wetlands on the slopes [3, 7]. As a result, on slopes where springs open up, the moisture content of the rock increases, while elsewhere the water table decreases and their strength increases.

Landslide control refers to the mitigation of the effects of landslide-forming factors and the complete elimination of some of them. Landslides occur due to various factors, and there are different types of them. For this reason, measures to combat them are also varied. For example, while underground column piles are installed against *consequent and insequent* types of landslides, retaining walls are erected on slopes where *deleapsing and detrusive* landslides occur.

In order not to dislodge the body of the landslide, underground column piles, retaining walls and counter dams are mainly used. This is done by calculating the size of the landslide body and the forces holding it in place. Only then will the retaining wall and column piles be able to hold back the body of the landslide.

Underground pile columns on slopes where there is a risk of landslide are drilled, and these boreholes are filled with reinforced concrete mortar. The piles of the column crossing the surface of rupture connect the body of the landslide and the mass not involved in the sliding (*Figure 3*).

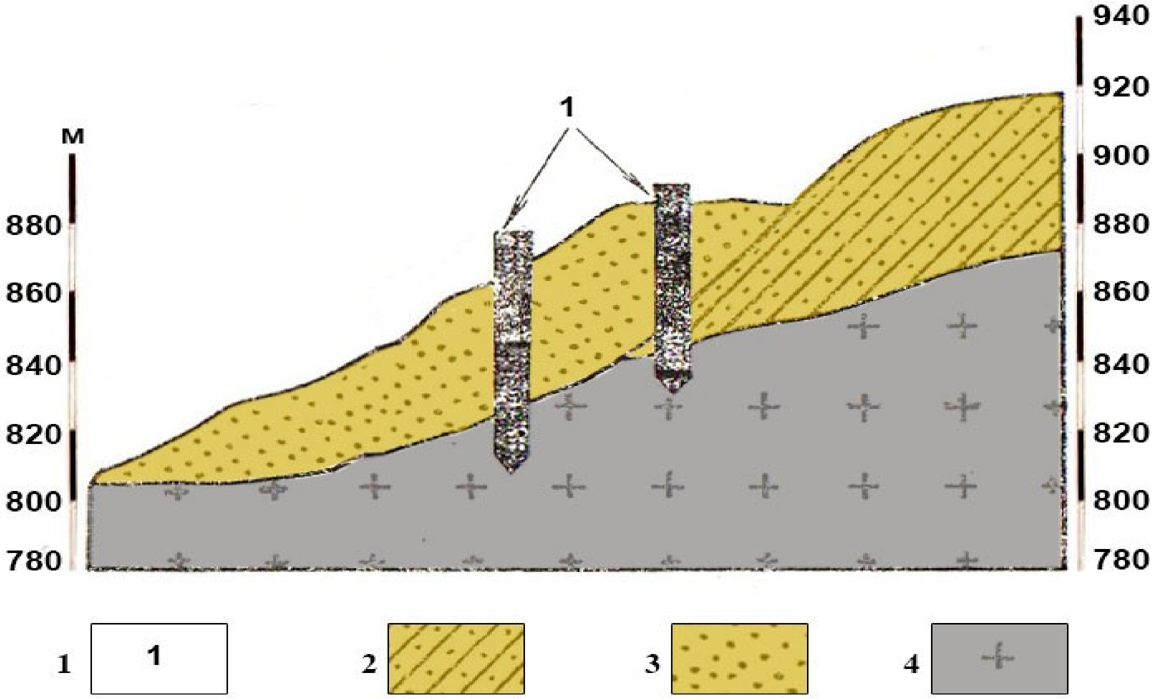

Figure 3. **Schematic section of strengthening the steep slopes of Sijjak terrace, where a landslide is likely to occur, by means of underground column piles.** 1– underground column piles; 2 – loess-like and clayey rocks; 3 - loess rocks; 4 - gravels and conglomerates.

Work to strengthen the slopes with such underground piles-columns was carried out in many places of our research facility. This measure will prevent the occurrence of landslides on the steep slopes around the Charvak Reservoir, the base of which consists of sediments of different periods, the upper part of which is covered by loess-like and clayey rocks.

During the construction of roads leading to the eastern, northern and southern areas of the Pskem recreation area and the Chimgan-Charvak recreation area, it was sometimes necessary to cross over the slopes of the Ugam, Pskem, Chatkal ranges with a high gradient, with relative heights of about 200-250 metres. As a result, the strength of mountain slopes decreases and the likelihood of landslides increases. In this case, one of the measures to prevent landslides is the construction of retaining walls.

Retaining walls are erected at the bottom of the slope to prevent rock sliding. Retaining walls reduce the likelihood of a landslide process and prevent highways from failing. To make sure these walls are stable and last for a long time, drains are built on the back of the slope. The function of drainage is to protect the retaining wall from destruction by collecting water coming from the top of the slope and between the body of the landslide.

When the landslide rock thickness and slope slope are small, counter dam barriers are most often used to stop the landslide. Such barriers increase the strength of the slope. To do this, the convexity at the top of the slope is cut away and placed on the foot of the slope (*Figure 4*). In this case, the slope slope decreases, and the force holding the body of the landslide in its lower part increases.

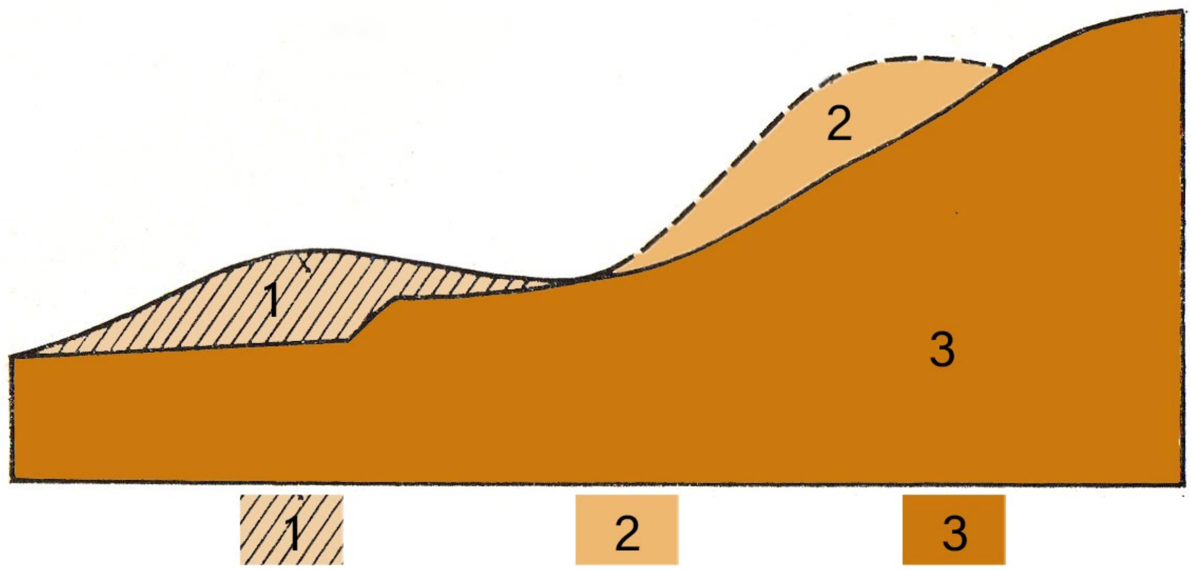

Figure 4. **Scheme to increase the strength of slopes by levelling their gradient and erecting a counter dam.**

1 - counter dam; 2 - site of cut-out convexity; 3 - base consisting of hard rock.

If there are sedimentary rocks beneath the landslide body that are not resistant to external influences, they will begin to deteriorate rapidly when the surface is exposed. In such cases, it is impossible to apply measures for the construction of a counter dam, cutting out the convexity on the slope. Such measures are carried out only if there are solid igneous or metamorphic rocks under the body of the landslide.

In addition, planting trees on slopes also helps to halt landslide processes for a period of time. To do this, on the slopes in a staggered manner, you should plant such long-rooted trees as walnut, poplar, pine. If the landslide body is no thicker than 4-5 metres, it will be very useful to plant a tree in such areas.

Conclusion and recommendations. When developing a classification of landslide processes and measures taken against it, attention should be paid to the factors under which this process occurs, the area occupied by it, the shape, the thickness of the landslide body and other similar characteristics. In addition, it can be said that the dynamics of a landslide depends on the magnitude of the impact of the factors involved in its occurrence. Because the degree of impact of these factors per unit of time is not the same.

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