# FEATURES OF THE FORMATION OF LANDSCAPE-FALL FAILINGS IN HIGH-ALTITUDE CONDITIONS AT INDIVIDUAL MINING SITES

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***ABSTRACT:*** *The article discusses the relevance of the problem, some issues of the mechanism of the development of landslide-failure caving (on the example of individual ore objects of the deposits of Uzbekistan). The research method included the study of not only the location of sinkholes, but also the sections located near sinkholes, since an important role in their formation is played by the flow of groundwater with active springs. In this regard, geophysical studies were carried out using the VES method, along the profile of the Guzhumsay field, which passes next to the sinkholes. As a result of the research, conclusions are drawn about the mechanism of development and the factors of the formation of failures and their influence on the development of deposits.*

The relevance of the problem, some features of the formation of landslide collapses are considered (on the example of individual high-mountainous objects of Uzbekistan deposits). The research methodology included the study of not only the location of the dip (collapse), but also the sections adjacent to the sinkholes, since an important role in their formation is played by the flow of groundwater with active springs. In this regard, geophysical studies were carried out using the VES method along the profile of the Gujumsay field, which runs next to sinkholes. The features of the development of the strength and deformation properties of rock

masses during the formation of landslide failure collapses, leading to changes in the mining and technical conditions for the exploitation of deposits, are studied. The characteristic of the failure of the earth's surface, which is formed as a result of the collapse of soils into mine workings, is given. The shape and size of dips are different, the most significant are typical for steep layers. The mechanism of development is given, which occurs in the following sequence: failed collapses are formed in places where cracking occurred at one time, which at the moment manifests itself as residual deformation; residual deformation is formed due to thermobaric processes developing during the deposition of ore objects; due to vibrational phenomena associated with mining operations, there is a weakening (decompaction) of cracks, which favors the migration of groundwater; due to water migration, due to constantly operating water inflows, through these cracks of groundwater flowing into the southern horizons; settles in the upper aquifers in the process of water overflow, suffusion processes occur, thereby creating favorable conditions for the formation of failed collapses.

## 1 INTRODUCTION

The urgent need to develop and develop at the modern level the mineral resource base of the Republic of Uzbekistan requires the commissioning of new deposits, the efficiency and safety of the development of which is determined primarily by the degree of knowledge and assessment of engineering and geological conditions (E.G.C). At the same time, it is required to reduce the time and costs of exploration by using the accumulated database and information on previously studied analogous deposits.

## 2 MATERIALS AND METHODS

An increase in recoverable volumes of rocks and depths of mine workings in the development of mineral deposits leads to an increase in the role of technogenic factors in the formation of hydrogeological processes. In connection with drilling and blasting operations and changes in mining schemes, the trends in the manifestation of technogenic processes that complicate the development of deposits are intensifying and provoke the development of various hydrogeological and engineering-geological processes. At present, the fund of near-surface, easily developed deposits is being exhausted at an increasingly rapid pace, and further expansion of promising ore regions can be carried out mainly due to the discovery of deep horizons in complex geological conditions, as well as those covered by rocks. For safe and efficient underground mining of a mineral deposit, it is necessary to conduct detailed hydrogeological and engineering geological studies. In this regard, the study of natural and man-made factors, their influence on hydrogeological and engineering-geological processes during the development of deposits, the assessment of their development, as well as the prevention and elimination of water inflows into mine workings today is an urgent and timely challenge of the time. Expansion of the resource base of existing enterprises requires a further deeper justification of the mining and technical conditions of operation, prevention and elimination of water inflows into mine workings, as well as the timely presentation of practical recommendations on drainage methods, which will allow the efficient and safe development of ore deposits. [1,4].

## 3 RESULTS AND DISCUSSION

When driving underground mine workings, difficulties arise due to pressure waters, the development of quicksands, karst voids and zones of increased karstification of rocks, the possibility of quicksand water and liquefied clay rocks breaking through into mine workings, turning into landslide-collapse collapses.

The location of the formation of the failure zone cannot be determined, since it depends on a combination of many natural and man-made factors. Vibrations, industrial explosions, underground waters and precipitation in abnormally water-rich years, penetrating through existing cracks and funnels, can accelerate and intensify the process of formation of the zone of rock displacement under the mined-out space. The main increase in the process of formation of failures occurs in November. Maximum water inflows into mine workings coincide with heavy precipitation. In 2012, 540 mm fell and, accordingly, the average annual water inflow into mine workings increased, reaching 40 l/sec.

Thus, based on these features of the geological structure (in this area there are rocks that are not consistent in thickness and strike, which are divided into different blocks), the mechanism of development of collapse collapses is determined, i.e. the state of stability of mine workings. Geological features are predetermined by the block structure of the mining region (field) and affect the degree of waterlogging of structural blocks by area and depth.

The Guzhumsay runoff directly depends on the amount of precipitation, the main runoff falls on the winter-spring period. According to Gujumsai, the maximum flow rate is 1446 l/s (April), the minimum 9,7 l/s (August), in 2017 the average annual flow rate is 50 l/s.

The geological structure of the Guzhumsay deposit includes intrusive rocks of the Paleozoic and overlying loose Neogene-Quaternary deposits up to 100 m thick. Intrusive rocks are represented by granosyenites, syenites, granites, Upper Pliocene - siltstones, clays with interlayers of gravelites and conglomerates. Quaternary formations overlap the Neogene rocks and are represented by alluvial-proluvial rubble sediments with fine earth. The Quaternary formations overlap the Neogene rocks and are represented by alluvial-proluvial rubble deposits with fine earth. Quaternary deposits are widespread and subdivided into 4 complexes: 1-Sokh complex (QIsh) is represented by conglomerates 3-5 meters thick; The 2-Tashkent complex (QIIts) is represented by light loess-like loams, less often sandy loams, their thickness does not exceed 20-30m; 3-Holodnostepsky complex (QIIIgl) is represented by loess-like loams, sandy loams, pebbles and sands, the total thickness is 20-30m; 4- Syrdarya complex (QIVsd) is represented by loess-like loams, pebbles with boulders, crushed stone, coarse-grained sand and gravel, the total thickness is from 5 to 40 m. [3].

According to the conditions of feeding, distribution, circulation and discharge within the field, the fracture waters of the Upper Paleozoic rocks and the fracture-vein waters of the zones of tectonic faults are mainly distinguished.

Hydrogeological studies of underground mine workings of mine 1 (regime monitoring of water inflows) showed that the main ways of groundwater inflow into the workings are zones of tectonic disturbances, zones of crushing and increased fracturing. As a result, fissure-vein waters are formed.

According to regime observations, well 1305 is located in the southwest of mine 1 at 1000-1500 m, the groundwater level varies from 41.0 to 62.0 m, well 3 is located northeast of mine 1 at 400-500 m, groundwater level varies from 76.83 to 103.56 m.

At the horizons +780 m, +720 m, +660 m, +600 m along mine 1, observations of total water inflows are from 35,7 to 136,0 l/s.

At the horizons +660 m, +600 m, along the NTS-5G mine, the observation period in 2017 into the water inflow was: horizon +660 m from 23,8 (June) to 18,4 l/s (March); horizon + 600 m from 3,5 (June) to 30 l/s (March).

According to the classification of N.I.Plotnikov, the Guzhumsai field belongs to the category of medium complexity in terms of the degree of complexity of hydrogeological conditions, which is also due to the thick stratum of flooded Neogene-Quaternary sediments, the presence of numerous tectonic disturbances, the predominant distribution of fractured-ground and fractured-vein waters, the proximity surface watercourse [7].

In the watering of underground mine workings, mainly fissure and fissure-vein waters of Paleozoic rocks are involved. The groundwater of Neogene-Quaternary sediments is also involved in the watering of mine workings, but due to the low values of the filtration coefficients of the bedrock, despite the significant reserves of groundwater, their flow into the mine workings is limited. It enters mainly through the zones of tectonic faults with higher filtration coefficients.

Tectonic fractures are mainly developed at the Guzhumsai field. In addition, there are unloading cracks of artificial origin. Tectonic cracks are represented by shear cracks, they are steeply inclined, vertical, and contribute to the formation of rock falls.

Most of them are made of quartz, chlorite, iron oxides, or ground material. Artificial (man-made) cracks have arisen under the influence of blasting and rock pressure. They are usually flat, horizontal with an angle of incidence of 40-45o.

Based on the results of fracture measurements, histograms were built. In the underground mine workings of mine 1, horizon +720 m, four systems of cracks are identified on the histogram:

I - dip azimuth 10-60 °; II- dip azimuth 80-140 °

III - dip azimuth 180-280 °; IV - dip azimuth 310-360 °.

Engineering and geological properties of rocks, which determines the features of the values of strength indicators of properties, stability and behavior in mine workings [8].

Analysis, generalization, and a comprehensive study of the hydrogeological and engineering-geological conditions of the field, allows to establish and identify an increase in water inflows into underground production adit horizons, to take the necessary safety measures in advance for mining operations in the mining massif.

During underground exploration and development of mineral deposits, the formation of collapse and fell out was widely developed. Collapse by confinement is inherited to horizontal and inclined mine workings and is formed:

- collapse of the roof of mine workings, which are formed in a domed shape.

The sinkholes of the funnel are formed by shallow horizontal mine workings passing along the zone of crushing faults, steeply lying ore bodies and in the presence of faults in the upper parts. In the processed ore zones, sinkholes are formed, the further development of which in deeper horizons undergoes subsidence of individual block structures. Weak zones are tectonic ruptures and large cracks, as well as inter-contact layers. They are mainly located vertically or at an oblique angle relative to the goaf.

Various types of deformation and type of displacement develop on the surface of the deposit. These are dips of rocks, sinkholes are interconnected, they can develop sequentially. Dips of rocks are formed in those areas where mine workings are laid on small deep along the zones of crushing faults above the upper part of the worked-out vein zones causes craters of collapse. Further developed which are located within the faults more forms deep horizons cone-shaped dips [5].

On June 17.2017. In the area from mine No. 1 of the Guzhumsay deposit 300-400m, a sinkhole appeared. The signs of the manifestation of which were initially the formation of cracks on the surface in the thickness of loess-like loams of coverage with a diameter of 30-35 m, a depth of capture to the second horizon of 245-250 meters.

Over time, arcuate cracks began to form outside the funnels; with time, the mouth of the funnels began to collapse. The identification and assessment of the conditions for the formation of the existing sinkhole craters, the places of its development, as well as the study of the geological-tectonic block structure of the ore zone and other areas in general, makes it possible to assume that in similar areas during mining during mining operations, large deformations are possible in the form of sudden subsidence large volume on the area of rock masses.

On September 18, 2018, the second sinkhole formed at a distance of 10-15 meters, and the first sinkhole expanded by 35-40 meters [5].

Parameters of the second funnel, diameter was 45-50m, with a capture depth of up to 240m.

Observation and study of the failure funnel as of 04.18.2019. According to the parameters of the first sinkhole, the funnel expanded by 2-3m, the diameters were 40-43m. The second sinkhole widened 4-5 m, diameters were 55-65 m, at a distance of 6-8 meters.

As a result of the development of the 55th ore deposit at the horizons of +780 and +720 m, two sinkholes were formed on the surface of the Guzhumsaya deposit in April 2021. The diameter of the first sinkhole is 15-20 m, and the second one is 60-80 m, their apparent depth is up to 35 m (Fig. 1).

Along the walls of the funnels, Quaternary deposits are traced, represented by sandy loamy and gravelly deposits with small interlayers of sand. Further along the section at the bottom, the roof of red-colored Paleozoic deposits is observed. From the northern side of the second funnel, at the contact of sandy-gravel deposits at a depth of 20 m, groundwater emerges at a flow rate of 5 l/sec. The filtration coefficient of the first failure is Kf = 18.0 m/day, the 2nd - Kf = 14.4 m/day, which may be one of the reasons for the formation of the failure. Under these conditions, mining operations accelerated the development of the sinkhole.

Additional studies were carried out to determine the causes of failed collapses. The research methodology also included a study by the VES method along the profiles that passed next to the failed funnels. It was found that an important role in the formation of sinkholes was played by the flow of groundwater with active springs (Fig. 2).

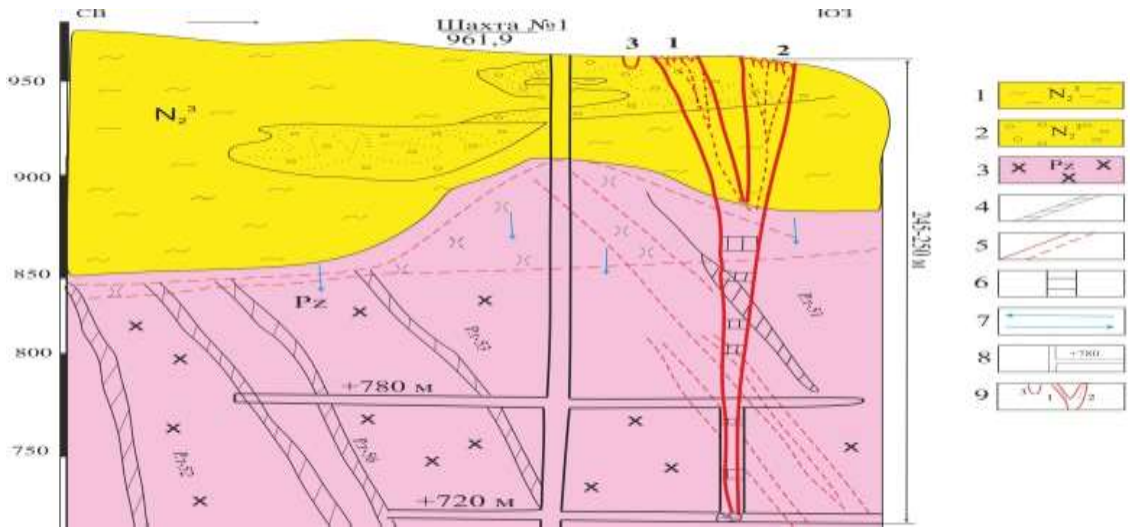


*Fig.2. Geological section of the Guzhumsai deposit.*

1—clays, siltstones and their age; 2 – small-pebble gravelstones and their age; 3 – weathering crust of granosyenites; 4 – ore bodies and their numbers; 5—zones of tectonic faults; 6 - barren space; 7 - movement of groundwater; 8 – mine workings; 9 - failed collapse.

The picture we have described reflects the state of the geological environment after the collapse developed in deep aquifers. This is due to the vibrational actions of subsequent mining operations, which affected the permeability of the Quaternary deposits overlying the fractured granosyenites.

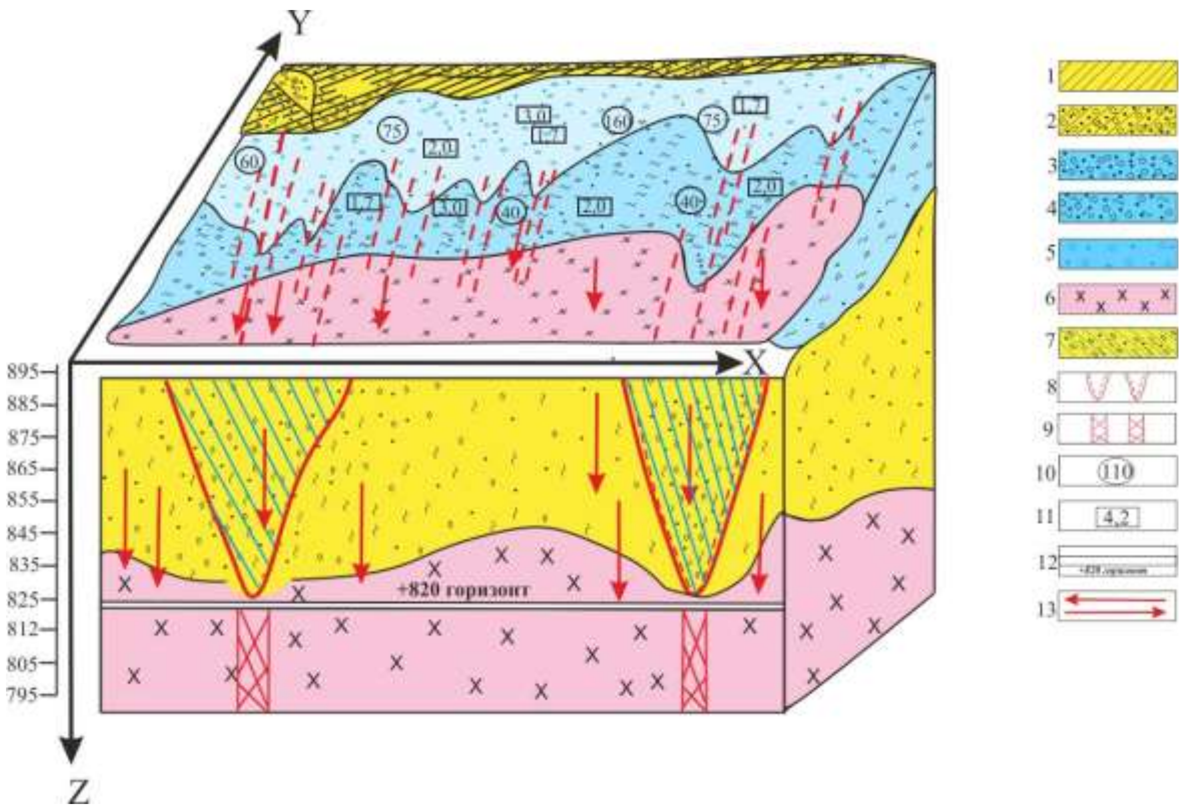


*Fig. 3. Block diagram of the collapse zone of the Gujumsay deposit*

*Neogene deposits:*

1 - loam, 2 - gravel and pebble with loamy filler; 3 - pebble with sand filler (Kf = 2 m/day); 4 - gravel and pebble with sandy-clayey filler (Kf = 2-3 m/day); 5 - gravel and pebble with highly permeable rocks; 6 - weathered granosients; 7 - gravel and pebble with sandy-clayey moistened filler; 8 - collapses; 9 - fault zone; 10 - specific electrical resistance, Ohm-m; 11 - filtration coefficient (Kf), m/day; 12 - underground mine workings; 13 - groundwater movements.

The process of vibrational phenomena had a noticeable effect on clay rocks, their cohesive strength, clay particles, which served as structural bonds. The subsequent overflow of waters caused the transfer of clay particles to the lower adit horizons (+720 m).

In the lower part of the section, thixotropic processes occurred in the Quaternary deposits, which led to a funnel-shaped collapse with a depth of 35 m.

Based on the results of electrical exploration and geological studies, a map of the location of the failed collapse, the failed collapse zone, taking into account the results of the VES, was drawn up, which clearly reflects the structure of the movement of groundwater in the failed collapse zone above the mine working. The completed scheme of the location of the failed collapse of the study made it possible to qualitatively and quantitatively characterize the main patterns of changes in the structure of stress and deformation fields in the rock masses of the ore and enclosing strata during the construction of mine workings.

In an undeformed mass, outside the zone of failed collapse, the cohesion is 27.5 MPa, the angle of internal friction is 55°, the strength characteristics for compression are 101 MPa and tensile strength are 7.3 MPa.

Mechanical properties of rocks in the collapse zone of a failed collapse: adhesion - 10 MPa, angle of internal friction - 52°. Strength characteristics for compression 63.8 MPa and tension 5.5 MPa.

In the collapse zone of a failed collapse, the strength indicators decrease (63.1%) due to the weakening of structural bonds in the rock mass, the angle of internal friction decreases by 1.06, respectively. Faults are almost absent outside the failed collapse zone; the rocks are massive.

In the lower part of the section, thixotropic processes occurred in the Quaternary deposits, which led to the formation of a funnel-shaped collapse, the depth of which reached up to 35 m.

The main reason for the formation of a sinkhole is the action of dynamic forces from the explosion and the operation of mining vehicles, as well as the unloading of overlying lithological rock varieties, which is accompanied by the removal of the rock mass by mining operations [4].

The above processes manifest themselves directly in the stress field as a result of the development of horizontal mine workings, in which, over time, the strength and deformation properties of rock masses change, leading to the formation of landslide collapses.

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The technology for the development of this section is carried out by a chamber-and-pillar system, leaving the pillars without laying the worked-out space for working out the interlock pillars, they are loosened by means of an explosion. Such a mining system causes a redistribution of stresses in the massif, which, depending on the depth and size of mining, the heterogeneity of the massif and the complex geological-tectonic structure, favored the sinkhole, and the cause is massive explosions and earthquakes, as well as the section of the sinkhole are directly located in the zone of tectonic faults which lie almost vertically 70-800.

Thus, the assessment of the conditions for the formation of the existing collapse of the place of its development, as well as the study of the geological and tectonic conditions of the ore zone and other areas, in general, makes it possible to assume that in similar areas during mining during mining operations, such a manifestation of large deformations is possible. the form of a failure of rocks on the surface of the deposit.

The main reason for the formation of a failure is the action of dynamic forces from the explosion and the operation of mining vehicles, as well as the unloading of the overlying lithological rock differences and the removal of the support by mining operations.

## CONCLUSION

The results of the studies on the Guzhumsay deposit are as follows.

1. During the mining and tunneling operations, the strength properties of the overlying layers weakened, resulting in the formation of wedge-shaped water-saturated zones in the underlying layers.

2. The most water-saturated zones have a directional character, which is directed toward the collapse zone.

3. As a result of the interaction in the collapse zone of water-saturated layers with vibration fields, a collapse developed. At the same time, thixotropic liquefaction is observed in its lower part, which led to the unloading of water-saturated zones in the adit horizon area (filtration coefficient Kf = 14-18 m / day).

4. During the formation of ore mineralization, thermobaric processes occur, which contribute to the development of fracturing above ore mineralization, which are noted for poor permeability during the driving of mine workings. The cracks in

question were deformed, making them permeable. It is through these cracks that groundwater seeps out.

5. In the overlying aquifers, the filtration coefficient of the loess-like loam occurring in the Quaternary deposits is 0.22 m/day.

6. The movement of water through the cracks excited the upper aquifer. As a result, the cohesion between rock particles was significantly reduced. The constant movement of water through the cracks led to a large degree of removal of clay particles, which served as cohesion in loose sediments. Thus, the removal of clay particles through cracks located above the ore mineralization led to the formation of a collapse collapse.

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