Monitoring and environmental features of development of Yahsu gold deposit (Yakhsu depression, Tajikistan)

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Abstract. On the territory of the Republic of Tajikistan, almost the entire spectrum of dangerous geological and natural-climatic phenomena is observed, and the solution of the issues of risk reduction from them is of paramount importance. The paper describes the geo-ecological problems associated with the change in landscape and geological environment in the area of gold deposits Yaksu. It offers a rational development mechanism described conservation measures necessary to restore the landscape of the area and offers the potential use of terrikons- waste mining activities. The amplitude of the erosion cut varies widely - from the first meters in the accumulation zones to hundreds of meters in the upper valleys.

1. Introduction
Gold scattered Yahsu’s field is considered as one of the leading mining branch of Tajikistan due to its securing the principle production of this precious metal in the republic, thereby emphasizing its important role in the economics. The deposit has been known since ancient times being developed for a relatively long time, that naturally led to infringing the stability of geological environment and arising a number of problems requiring undelayable solutions. It is known that the state of the geological environment has a direct determining impact on the state of the inhabit environment, thus serving as a kind of a sensitive indicator of the territory subject to intense anthropogenic impact [1-6]. Although the geological environment as one of the most important components of the inhabit environment on the gold deposit Yakhsu site and adjacent areas was under [7] the influence of anthropogenic factors for a long time, the most tangible intensification of negative processes is observing due to the irrational mining methods conduct in the last few decades [8-9]. The transformation of nature under the anthropogenic factors, permanently amplifying in the course of
progress in the field of tools and mining technology and the grading scaling of ones, has led to the need to assess the areal environment’s negative transformation, like other objects [10-14].

2. Objects of research
The study area is located in the Khatlon region, in the southwestern part of the Republic of Tajikistan. The territory borders the Panj River in the south, forming part of the international border with Afghanistan [9].

Geologically the Yakhsu deposit is located within the homonymous cavity Tajik depression. The deposit area is composed of coarse clastic poorly sorted clastic rocks of Neogene age (Tavildara, Karanak and Glizak suites) with a thickness of more than 5000 m [8,15]. Present deposits are represented mainly by alluvial, alluvial-proluvial, rarely colluvial varieties [15-16].

3. Object analysis
The signs of field mining by ancient miners most clearly traced along the southern edge of the Safeddara river’s site, where the slopes, composed of modern sediments, are partially or completely have been worked out.

Among geological processes that affect the landscape area of gold deposit Yakhsu, the leading role belongs to exogenous geological processes [8,15-19]. There were the basic exogenous geological processes spread out. In descending order of areas extracted from the economic use by these processes they are distributed in the following order: gully erosion, river erosion, landslides formation [20]. It is also a proliferation of ground subsidence in the area of loess, a planar flush of soils with transgressed soil protective vegetation.

Gully erosion. The largest land areas diverting out by ravines of economic involvement marked in the eastern part of the deposit location in the basins of Safeddara, Muchkakion, Bomavlo and Hirgodara rivers, in Yokunj river basin within the plateau Dashtak. All of these river-affluxes of Yakhsu are temporary, as almost completely drying out in the summer-autumn terms (Figure 1).

![Figure 1. Gully erosion.](image-url)
• the landslides in the Quaternary sediments, associated with the deformation of clay glacial and overburden ones, are developed widely; for they morphological type ones are circle like, by the depth of capture it’s surface and shallow (<5 m), by the displacement mechanism it’s shear landslides and flows. In the southeastern part of the village of Sarkoron, circus landslides are also visible (Figure 2);

![Figure 2. Circus: 1-2 – landslide circuses.](image)

• the landslides in Neogene sediments, associated with the deformation of clastic rocks, are common in these places in the area between the rivers Obipitovda and Kapar; morphologically they are attributed to frontal type, by the depth of capture are deep ones (over 5 m). Affected areas by landslides are uneven, from hundredths parts to several dozen landslides per 1 km².

River erosion. The most noticeable is this process on major affluxes of Yakhsu river and by side vicinity. It removes from the economic use the lands on floodplains and valleys’ boards, activates the landslides processes and gully’s’ growth. Quantitative assessment of this process for the deposit location area is unknown [19] (Figure 3).

![Figure 3. Swimming pool Safeddara, Muchkakion, Bomavlo and Hirgodara within the Dashtako plateau.](image)
The total affected areas by exogenous geological processes aren’t more than 5-9 %, but these processes are usually most active and noticeable in the areas of mining works and the intensive economic activity, often posing a threat to economic entities.

4. Methods
The proper solution of geo-ecological problems in the area of the deposit field we assume appropriate the following requirements: a) selection of complex mechanization structure for the mining of scattered deposits; b) geo-ecological monitoring as a system for assessing the state of the field; c) integrated mining and deep non-waste or low-waste processing of raw materials, d) the adoption of the concept of nature’s conservation under the extraction of ore, as well as issues related to secondary processing and recycling the resulting waste dumps (heaps).

When choosing a method of development of the scattered deposits Yakhsu there is a need for a comprehensive study of composed mechanization structure. Since mining and mining-geological parameters of scattered deposits Yakhsu vary within certain limits and not always the mining in the same way is an effective, a broad implementation in the mining and stripping work should get more efficient combined scheme: dredge (dragline), bulldozer-excavator (mechanical spade) vehicles, bulldozers-hydraulic transport, bulldozer-conveyor-stacker, as well as other well-known schemes. These will streamline and intensify mining and stripping operations in the field, reduce the time of scatterings work out, reduce the expenditures of 1 m3 rock mass’ processing and increase productivity.

If before zero years the initial idea of creating geo-monitoring system, which is understood as organized under the controllable and forecastable prophylactic purposes observing system for the development of the geological environment, found adherents, mostly in the camp enthusiasts, at the present time it is implemented in practice in many republican geological sites. Observational system on the geological environment in the area of gold scattered deposits of Tajikistan isn’t conducting on, though there are enough negative factors accumulated, the solutions of which are adjoined with the use of this system in the area. Geomonitoring data are to be used for modeling of the geological environment by comparing the assessments with the system standard criteria and indicators. It is obvious that the mining of gold deposit Yakhsu should be accompanied by monitoring of the impact on the geological environment in order to control this exposure and development on the basis of the preventive measures foreseen. At the same time the crucial regulatory role is to play directly by the state authorized units in the capacity of survey of conducting the geological environments’ state monitoring. Taking the tasks on geological environment monitoring for deposit Yakhsu, it must ensure compliance with the three main stages in the monitoring service: 1. Creation of the observing system in the facility site and surrounding area, including the program of work and survey of observations; 2. Conducting the observations and data transmission to the state survey of geological environment monitoring for generalization of information as a whole and subsequent modeling and forecasting; 3. On results of observations and management taking due forecast decisions.

Considering the above mentioned the following highlight key issues are to be assumed: 1. Composition of observable components of the geological environment; 2. Principle of the organization of observation points on geological environment and their arrangement; 3. Methods of observations, including observational means, sampling frequency (of observations).

5. Research results and discussion
In gold deposit Yakhsu mining there a significant amount of both developed space and waste heap dumps raised up, where the issues of disposal of the latter grew into one of the most important field problems. Taking into account the current level of extraction production technology development, as well as the fact that these piles contain a significant amount of useful components (Au, Ag etc.), we consider the complex issue of mining and utilization as a very important one. It is known that the mineral raw materials’ extraction in the gold ores scatterings is producing at the boundaries of ecosystem, the main components of which are in different states (solid, liquid and gaseous). The system’s interaction parameters in each case are different and depend both on the man-made factors
and the mechanism of the influence of the elements of the system relative to each other and secondary physical and chemical processes in the mineral masses. But, fortunately, the geoeconomic situation from the standpoint of environmental pollution by toxic substances at the facility site is still favorable. The results of chemical analyses of samples of habitat medium display, that natural water in the deposit area don’t contain significant amount of heavy metals, this is partly due to mainly mechanical mining of the deposit field.

The foregoing allows us to state that the application of modern conservational technologies for the extraction of raw materials depends on the interaction of implementation mechanism and structural elements of the system, as well as their feasibility. The most promising conservation environmental technology of mining in putting on stowing hardening mixtures, hasn’t yet received proper spreading because of high cost. Besides, the use of this technology is limited by possible further negative interaction with the components of the environment and its unsuitability for use for the given considering type deposits.

6. Conclusion

Thus, summarizing the above said, one can note the following:

1. In general, the geo-ecological problems in deposits Yakhsu mining are reduced to a transformation in the landscape by mechanically way and the intensification of a number of engineering and geological processes of exogenous variety;

2. In order to solve the problems of geo-ecological problems turned up here it’s recommended conducting series of measures to restore the landscape, including lands and the slopes reclamation, and construction of bank and slopes strengthening structures, backfilling waste pits, etc.

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