The influence of the gold mining enterprise Aprelevka (Tajikistan) on the state of the atmospheric air and landscapes

A A Aleinikova, T D Gaivoron, M K Karimova, G M Mainasheva and N V Marsheva

1 Ecological Faculty, Peoples’ Friendship University of Russia, 8, Podolskoe shosse, 5, Moscow, 115093, Russia
2 Institute of Natural Science and Sports Technologies, Moscow City Pedagogical University, 1 Chechulina Str., Moscow, 105568, Russia

E-mail: tdgsiv@gmail.com

Abstract. Mining enterprises affect the complex of natural conditions: geological structure, relief, atmosphere, watercourses, soils, vegetation, landscape, and change the quality of life of the population. The development of the mining industry in Tajikistan can lead to a deterioration of the environmental situation. Investigations in the area of the Aprelevka gold-mining quarry in the central Karamazar ore region have shown that all components of desert landscapes and especially atmospheric air are very vulnerable to man-made impacts. The study of the results of industrial environmental monitoring of atmospheric emissions at gold mining enterprises showed that environmental standards of the Republic of Tajikistan are observed, the air purity in the region is preserved. The negative impact on the quality of atmospheric air is observed only at the enterprise. Employees of the enterprise must use protective equipment.

1. Introduction
A Tajik-Canadian joint venture for gold mining “Aprelevka” is in the village of Kansai, 50 km from the city of Khujand, in the ore region of Karamazar. The enterprise includes several quarries, a gold recovery plant, a tailings facility, a chemical laboratory, an electromechanical workshop, a repair and construction site, a car garage, and water intake facilities. Field development began in 2002.

According to its production purpose, the enterprise is engaged in the extraction and processing of ore with the subsequent extraction of gold and silver in the form of a Dore alloy, suitable for subsequent refining.

Currently, sulfide ores of the Burgundian deposit are involved in processing. In addition to gold and silver, the ore contains copper – up to 0.8%, as well as selenium and tellurium.

Numerous deposits and ore occurrences of lead-zinc (with silver) and copper ores, fluorite, barite, arsenic, bismuth, gold, silver, tungsten, and molybdenum have been discovered in the Karamazar ore region. There are aluminum raw materials (alunite, diaspora), iron ores, and several other ores of skarn, hydrothermal, telethermal types, genetically related to Late Paleozoic magmatism [1].

2. Problem statement
Mining enterprises significantly change the complexity of natural conditions, landscape components: rocks, geological structure, relief, atmosphere, watercourses, soils, vegetation, landscape, and affect the quality of life of the population.
The impact of opencast mining of gold and other ore components on the atmospheric air, in contrast to the impact on other components of the landscape, spreads with air masses over greater distances, which negatively affects the landscapes, settlements, located tens of kilometers from the quarries. Therefore, zones of the direct and indirect impact of open-pit mining on the environment are distinguished [2].

The purpose of the work is to determine the impact of the gold mining enterprise Joint Tajik Canadian Limited Liability Company “Aprelevka” on the state of atmospheric air, landscape components, and landscapes in general.

3. Materials and methods
The research was carried out in the “Aprelevka” gold-mining quarry of the Karamazar ore region. The calculation of emissions into the atmosphere was carried out according to the methodology “Calculation of harmful emissions (discharges) for a complex of equipment for open-pit mining” [3]. Emissions from the following sources of air pollution were estimated: drilling operations, blasting operations, vehicle operation for the period 2015–2019.

4. Results discussion
The Aprelevka ore deposit is located on the slope of the southeastern exposure of the Kuraminsky ridge, within the Asht district of the Sughd region of Tajikistan. The absolute height of the territory is from 1900 m to 3700 m. The ridges of the ridges are narrow, rocky, peaked peaks, steep slopes, with rocky cliffs (up to 200 m high). On the slopes, active processes of water erosion, denudation take place, erosion forms of temporary streams – sais are formed. In the lower parts of the slopes, there are hilly-ridged foothills – adyrs. At the foot of the mountains, piedmont accumulative proluvial plains and terraces of the Syr Darya river were formed.

Figure 1. Geographical location Joint Tajik Canadian Limited Liability Company Aprelevka [4]

The main ore-bearing structures of the region under study were formed during the Caledonian and Hercynian tectonic-magmatic cycles. A thick stratum of volcanogenic formations of the Upper Paleozoic age has accumulated.

The Caledonian structural-magmatic complex is represented by sandy-shale and volcanic strata of the Ordovician – Lower Devonian, 5000 m thick. The occurrence of the rocks of the complex is very insignificant.

The Hercynian (Late Paleozoic) structural-formational complex is composed of formations of the Middle Devonian – Upper Permian. The complex is represented by three structural tiers.
The lower one is composed of a Middle Devonian – Lower Carboniferous carbonate stratum, 2500 m thick.

The middle stage is composed of terrigenous and volcanic rocks of the Middle Carboniferous, about 900 m thick.

The upper stage consists of layered volcanic of the Middle Carboniferous – Upper Permian, about 1000 m thick.

In the central part of the field, there is a chain of dyke and dyke-like bodies with a thickness of 1–2 to 10–15 meters and a length of up to 2 km of land strike and almost vertical dip. In terms of petrographic composition, dike rocks are composed of granite-porphyry and felsite-porphyry.

Granite-porphyries are in the central part of the deposit, spatially associated with silicification zones, and are cut by a network of small quartz veins with gold mineralization.

Ore bodies in the Aprelevka open-pit mine are quartz-carbonate veins and zones of intense vein-dispersed mineralization, bearing gold and silver mineralization in industrial proportions.

The deposit produces ore with relatively high gold and silver grades, with an average grade projected for 2012 of over 3.5 g/t gold and over 25 g/t silver.

Almost 95% of the deposit area is covered by Quaternary sediments, represented by sandy loam, loam, deluvial and proluvial sediments. Their thickness ranges from 5–10 to 30–40 meters, gradually increasing to the south [5–7].

The climatic conditions of the study area, despite its relatively small territory, are quite diverse, which is due to the significant dissection of the relief, differences in the absolute height, and the exposure of slopes.

The climate is desert, characterized by cool winters (average January temperature from –20 to –80), hot summers (July temperatures from 280 to 350), low average annual precipitation (200 mm/year), and their uneven distribution. The average annual air temperature is 60–110 [8].

Wind rose in Sogd region

Figure 2. Wind rose of the study area [8]

The prevailing north-west and north-east winds are directed away from quarries to settlements, which can pose a danger of air pollution in settlements.

The southeastern slope of the Kuraminsky ridge is characterized by a desert zonal type of altitudinal zonation of landscapes.
Altitudinal belts replace each other from bottom to top from the desert, on the foothill plains to semi-desert, steppe, forest-meadow-steppe, subalpine-meadow on the slopes of the ridges to alpine-meadow-steppe on the tops [9]. Desert and dry steppe landscapes of the Kuraminsky ridge are very vulnerable to various types of anthropogenic activities, including mining.

The production site of the quarry is a zone of the direct impact of technogenesis. At the same time, the geological structure and relief of the territory of the quarry are radically changing, new technogenic landforms are emerging, i.e., lithogenic components of landscapes, which dramatically affect the sustainability of landscapes. Natural landscapes with this type of anthropogenic impact are destroyed.

The zone of the indirect, mediated influence of the gold-mining quarry includes the adjacent territories of mountain ranges, their slopes, which are characterized by the alienation for mining of agricultural lands of natural landscapes. In the conditions of the mountainous relief of Tajikistan, such natural geodynamic processes as landslides, avalanches, taluses, mudflows are activated.

Waste rocks from the quarry are located on steep slopes and in dry beds of the sais, where they form plateau-like and ridge-like dumps. The steepness of the slopes of the dumps can reach 25–430, more often 32–37°, there is a significant content of rocky coarse rocks (from 45 to 93 %) without clay filler.

The worked-out dumps differ sharply from natural landforms. On the steep slopes of the dumps, processes of physical weathering, gravitational processes, slope washout, and linear erosion occur. These processes form erosional mudflows.

In the last two decades, the activity of the earth's surface collapse has been catastrophically increasing. This type of natural and technogenic process is widespread in all ore fields of Karamazar and harms all components of the geological environment [10].

In the territories adjacent to the quarry, depletion and pollution of underground and surface waters, dehydration and salinization of soils, degradation of vegetation cover, and changes in the natural habitat of animals occur. Thus, natural ecosystems and landscapes are largely disturbed.

Air pollution during gold mining in the Aprelevka quarry occurs as a result of the following types of work: drilling and blasting, extraction and loading, the formation of overburden dumps and ore warehouses, the work of vehicles.

Drilling of the main wells is carried out with roller cone drilling rigs SBSh –250 MN. Blast holes are drilled to the entire height of the double ledge, and the excavation of the blasted rock mass is carried out in two stages: initially, the upper layer of the blasted mass with a height of 10–12 m is worked out, then the lower one. BTS-150B rigs are used for a good drilling.

Blasting operations are one of the main causes of ledge collapses, falls, landslides, and flattening of slopes. Excavation and loading operations on the overburden of ore bodies are carried out with EKG-5A excavators, for ore mining – with EO-5124. Technological and external transports are also used, which emit harmful substances into the atmosphere.

According to the study, several major pollutants are emitted into the atmosphere (Table 1).

| Emissions tons/year | 2015   | 2016   | 2017   | 2018   | 2019   |
|---------------------|--------|--------|--------|--------|--------|
| Solids              | 256.19 | 337.07 | 384.03 | 434.01 | 398.92 |
| Sulfur oxide (SO2)  | 0      | 0      | 0.79   | 0.80   | 0.85   |
| Carbon dioxide (CO2)| 3.29   | 4.33   | 8.70   | 4.92   | 3.85   |
| Nitric oxide (NO2)  | 0.86   | 1.96   | 3.33   | 1.85   | 1.31   |
| Hydrocarbons (CxHx) | 2.04   | 1.87   | 4.95   | 4.59   | 2.74   |
| Are common           | 252.39 | 345.23 | 401.81 | 446.17 | 407.66 |

More than 90 % of air emissions are dust (metal, cement, wood, abrasive). For the period 2015–2019, effective cleaning of emissions from dust was carried out (Figure 3).
Figure 3. The volume of annual dust emissions into the atmosphere 2015–2019

At the Aprelevka enterprise, industrial environmental monitoring is carried out, which makes it possible to track negative changes in the environment and respond to them promptly, as well as a set of technical measures aimed at preventing atmospheric pollution.

When carrying out drilling and blasting operations in a quarry, rigs with dust suppression with an air-water mixture are used. Also, hydro-dedusting is carried out during loading and unloading operations, road irrigation, both in the quarry and on the access roads. The efficiency of such dust suppression is 92–98%.

In general, the activities of the Joint Tajik Canadian Limited Liability Company “Aprelevka” comply with the current legislation on compliance with environmental standards of the Republic of Tajikistan [11]. As a result of the research, no excess of the maximum permissible emissions into the atmosphere was found. The negative impact of dustiness from work in the quarry extends only within the territory of the enterprise, which poses a danger to the workers of the enterprise.

5. Conclusion
As a result of the study, it was revealed that the main type of impact of open-pit gold mining in the Aprelevka quarry is the direct destruction of natural objects – rocks, relief, soils, vegetation, landscapes – in local areas within the mining allotment. Outside the mining lease, the main impact is due to dusting and emissions of pollutants from engines of road construction equipment and vehicles.

The main emissions of pollutants at the Aprelevka open pit are inorganic dust, carbon monoxide, and nitrogen dioxide.

The prevailing wind direction is north-west, north-east, in the same direction from the quarry of the enterprise are the main settlements, which creates a potential danger of the negative impact of quarry mining on the health of people living there.

A set of measures for dust suppression at the Aprelevka enterprise allows reducing dust emissions by 92–98%. The negative impact of dustiness from work in the quarry spreads only within the territory of the enterprise, which makes it necessary to use protective equipment by the workers of the enterprise.
Industrial environmental monitoring is carried out at the Aprelevka enterprise, which makes it possible to track negative changes in the environment (lithogenic base, water bodies, atmosphere) and respond to them promptly.

In general, the activities of the enterprise "Aprelevka" comply with the current legislation on the observance of environmental standards of the Republic of Tajikistan.

The rational and comprehensive use of minerals and the protection of the geological environment as one of the main directions of sustainable development of the regions of Northern Tajikistan are of decisive importance.

To preserve the natural environment, it may be advisable to organize protected areas – ore, mineralogical, geological, landscape, which will preserve not only lithogenic components but also mountain desert landscapes that are especially vulnerable to anthropogenic impact.

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