ISSN 1607-4556 (Print), ISSN 2309-6004 (Online) Геотехнічна механіка. 2017. №132

UDC 622.271:502.53.004.67

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MODERN METHODS OF RECLAMATION OF DISTURBED LAND LANDSCAPE IN TERMS OF OPEN-PIT MINING OF HORIZONTAL DEPOSITS

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СУЧАСНІ СПОСОБИ ВІДНОВЛЕННЯ ЛАНДШАФТУ ПОРУШЕНИХ ЗЕМЕЛЬ ПРИ ВІДКРИТІЙ РОЗРОБЦІ ГОРИЗОНТАЛЬНИХ РОДОВИЩ

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СОВРЕМЕННЫЕ СПОСОБЫ ВОССТАНОВЛЕНИЯ ЛАНДШАФТА НАРУШЕННЫХ ЗЕМЕЛЬ ПРИ ОТКРЫТОЙ РАЗРАБОТКЕ ГОРИЗОНТАЛЬНЫХ МЕСТОРОЖДЕНИЙ

Abstract. The article presents analysis of current techniques used for landscape reclamation and water-exchange process restoration in the disturbed geological environment in the process of the dump formation and reclamation at excavating of horizontal and flat-dipping deposits. Interrelations between directions of the quarry face advancement and streams of surface and ground water flows as well as their influence on efficiency of technological processes of the open-pit mining operations were determined. The determined expedient direction of the quarry face advancement makes it possible to restore the surface relief to the level almost similar to the natural one. Scheme of layer-by-layer technical and biological reclamation of the disturbed lands for their further use in agriculture is represented.

Keywords: open-pit mining, direction of the quarry face advancement, inner mine dump, disturbed geological environment, reclamation, restoration of landscape.

Topicality. Development of mining industry involves disturbance of geological environment being stipulated mostly by the increase in the share of open-pit mining operations. New man-made objects have been formed within the territories of natural landscapes: open-pits, mine dumps, waste piles, and sludge dumps. Such new man-made formations have changed geomorphological and hydrological structure of the region resulting in climate microchange as well as changes in soil and plant cover. Reclamation is one of the preventive measures to restore land capability after its man-made disturbance as well as to stabilize ecological state.

The objective of the paper. Substantiation of the reclamation of landscape and water exchange processes within the disturbed geological environment during the process of mine dump formation and reclamation in terms of open-pit mining of horizontal and flat-dipping deposits. Reclamation of lands suitable for agricultural use.

Statement of basic materials. Land surface under which certain mineral occurs (the one to be mined by the open-pit) is represented either by flat land or by disjointed ravines and hollows.

The natural landscape is of great importance for water exchange processes within geological environment. The mouths of ravines run into rivers supplying them with surface water in the form of atmospheric precipitations. Moreover, they are involved into the discharge of underground water level. It should be noted that quaternary deposits in natural geological environment have the properties of the system in which the rocks (loesslike ones) with high filtration parameters cannot retain water (atmospheric precipitations). Rocks with low filtration parameters (clays) retain water while sands and partially loesslike rocks accumulate it. That allows accumulating the water of winter-autumn period being main in terms of water supply for plants. The aeration zone is available. Thus, rocks with various physical and mechanical properties develop water exchange system within natural geological environment.

Man-made geological environment in the form of internal mine dumps results in the disturbance of water exchange system: vertical pores are eliminated and rocks act as a water-tight stratum; aeration zone is not available. In terms of open-pit mining, flat internal mine dumps are developed. As a result, surface and ground water flow are destroyed; water supply for rivers and underground water levels is disturbed. Hence, it is quite topical to study the possibility to form original landscape and restore water exchange processes within the disturbed geological environment in terms of open-pit mining of horizontal and flat-dipping deposits.

Results of previous studies. A lot of studies have been carried out in the sphere of reclamation of the earth's surface disturbed by open-pit mining [1-9]. The paper by A.Yu. Drizhenko [4] stresses on filling the ravines and other inarable lands with black soil, i.e. the emphasis is on so-called earthing. That will not allow either improving soil properties or facilitating water exchange processes within the disturbed environment. The paper by A.M. Laznikov [5] proposes not to reclamate but to revalue lands. That means developing man-made landscape by means of constructing ponds, recreation zones etc.

According to the legislation, mining enterprises lease the land. In the majority of cases, the terms of leasing tells that if the land is leased for agricultural purposes, it should be returned for agricultural purposes as well. In this context it is not allowed changing target purpose of the land. That is why the requirements for land reclamation are toughened considerably. In this context, paper by M.S. Chetverik and E.A. Voron [6] represents the study of layer-by-layer mining and biological land reclamation. However, the paper does not examine as well the landscape restoration to be close to the original one.

Sequence of the studies:

1. To consider the types of surface relief to be mined by the open-pit.

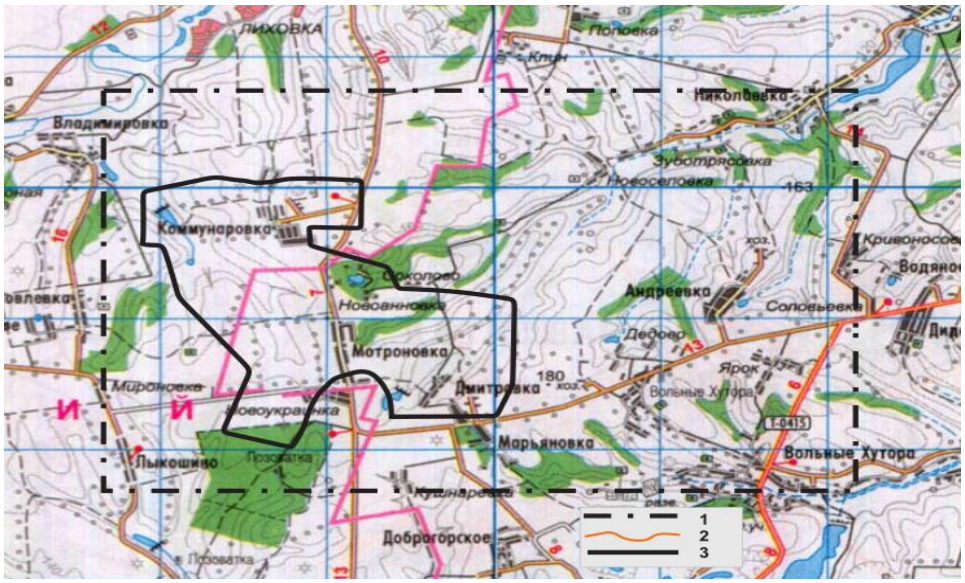
2. To determine the expedient direction of the displacement of open-pit mining operation front making it possible to reclamate the surface relief to be almost similar to the natural one.

3. To analyze the peculiarities of applying layer-by-layer mining and biological land reclamation in terms of the landscape formation conditions.

Types of surface relief to be mined by the open-pit.

Surface relief while developing manganese deposits within Nikopol manganese

field, Malyshevskoie zircon-rutile-ilmenite deposit in Volnogorsk etc. has been analyzed. It shows that the mining process results in the breaking of ravines involved in surface and ground water discharge. In this context, surface relief of Motronivka-Annivka zircon-rutile-ilmenite deposit is the most characteristic one (Fig.1).



1 – zone of modeling of water inflows into the prospective open-pit; 2 – watershed boundary between the ravines; 3 – ultimate open-pit boundary (according to A.M. Laznikov)

Figure 1 – Map of Motronivka-Annivka deposit relief

The territory of the prospective open-pit borders with the villages of Dmitrovka, Mariianovka, Novoukrainka, Motronivka, Novoannivka, and Kommunarovka. Open-pit field dimensions are 6.25×4.0 km; its area is 1760.0 ha. The terrain represents the flatland with ground levels being 170 – 180 m disjointed by the valley of the river of Domotkan with its confluents – Storozhivka, Gorobtseva ravines with the depth down to 70 m (Fig. 2.). Slopes of ravines are gentle, convex; the bottom is flat. Maximum surface slope is 2 %.

Ravines join near the village of Zubotriasovka. Here there is a bog lake showing the underground flow discharge. Hence, it can be concluded that the destruction of ravines while deposit mining will result in ground water flow destruction as well.

The analysis of surface relief of various areas of the terrain, where open-pit mining operations are planned or being carried out, shows that they are in the form of a tree branching when small ravines joins with large ones and finally run to the discharge objects by the main mouth.

The formation of a flat mine dump involves underflooding and salting of soils due to insufficient flow of atmospheric precipitations from subhorizontal surface formed by low-permeability clay loam soils. Nonuniform settlements of mine dumps result in drainless falls which accumulate water after rains and snow melting. In spring plants die as a result of underflooding while in summer water evaporates intensively with the formation of solonetz soils.

ISSN 1607-4556 (Print), ISSN 2309-6004 (Online) Геотехнічна механіка. 2017. №132

Figure 2 – Ravine within the area of the initial mining operations

Determination of the expedient direction of mining operation front.

Selection of the mining operation front direction is of considerable importance being based on the mining operation mode and overburden operations as well as on the safe work practices to eliminate landslide processes. It is essential while forming man-made landscape being close to the natural one.

Consider displacements of mining operations when the front will be perpendicular to the thalwegs of ravines. In this case it will be possible to have uniform mode of mining operations to extract annual amount of overburden and ore. However, the number of open-pit benches and their height will change along the length of mining operation front. Total height of open-pit will be lower at the points where mining operation front will cross the thalwegs of ravines. From the viewpoint of the formation of inner overburden rock dump as well as the formation of surface landscape being similar to the natural one, such development of mining operations is expedient. Nevertheless, it can result in significant landslide processes as mining operation front can cross the travel of ground and surface water along the thalwegs of ravines. It is especially characteristic for the conditions of Zavalievsk graphite integrated works (Fig. 3).

Since 1963, 15 landslide deformations have occurred within the open-pit. Analysis of hydrogeological and hydrological conditions of the surface relief near the river of Yuzhnyi Bug and the open-pit has shown that the main reason of landslide processes within northern and northern-western open-pit sides is the disturbance of underground and surface water as the result of the developed man-made geological environment represented by the open-pit and mine dumps. It happens as a result of the fact that northern open-pit side crosses three large ravines along its strike with the considerable hydraulic incline: eastern, central, and western ones. The ravines (before the open-pit development) supplied the river of Yuzhnyi Bug with water and displaced to the south from the existing open-pit. The supply was possible owing to surface water flowing along the thalwegs of ravines and ground water flowing out of the

ravine sands.

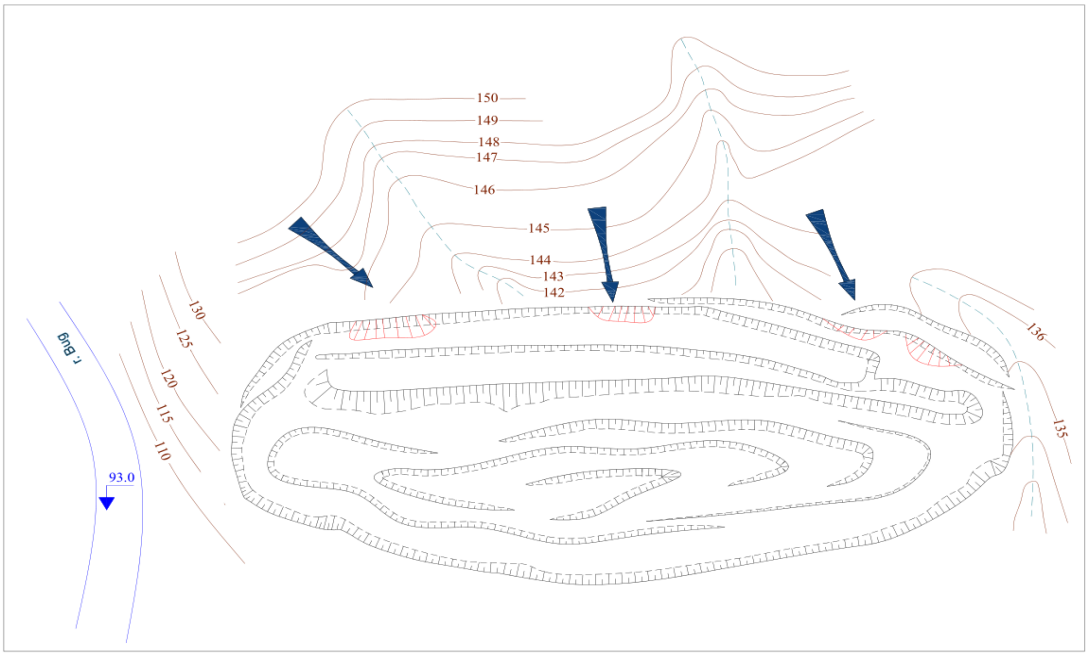


Figure 3 – Open-pit of Zavalievsk graphite integrated works [7]

Thus, landslide processes occur when northern side exposes the zones of motion (flows) of surface and ground water. The flow of ground and surface water is directed from the ravines to the open-pit (Fig. 3).

Development and substantiation of layer-by-layer scheme of mining and biological reclamation of the disturbed lands in terms of landscape formation.

According to the review of scientific papers dealing with the issue under study, we have faced the fact that in the majority of cases land surface reclamation after mining results in the even surface within the areas with previous ravines; in this context, reclamation does not involve the restoration of surface discharges to accumulate atmospheric precipitations, according to the papers by Lozhnikov and Cherep [8].

To develop the technique, it is possible to be based on the principle of layer-by-layer mining reclamation proposed by Chetverik and Voron [6] (Fig. 4).

The essence of layer-by-layer mining and biological reclamation is in the development of capillary system represented by root system of plants within the layers of potentially fertile rocks. It allows restoring the properties of natural soil.

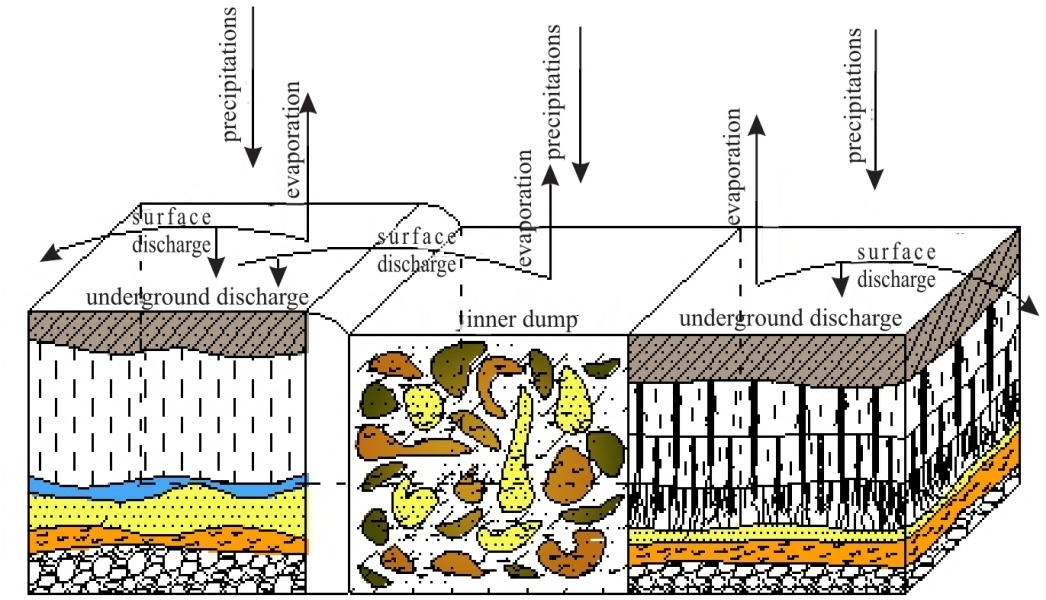
However, the technique does not involve:

1) the supply of water-bearing levels of surface rivers;

2) the restoration of surface discharge to accumulate atmospheric precipitations aimed at river supplying.

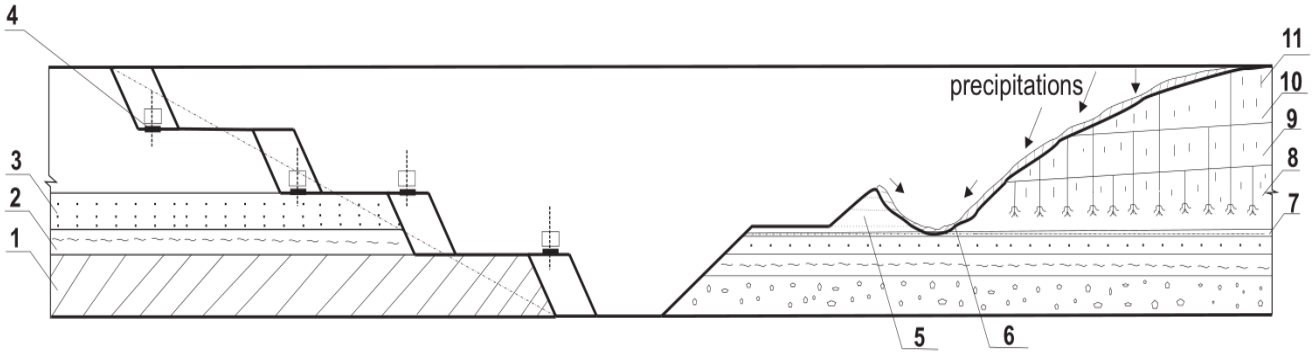
That is why, according to the determination of the expedient direction of mining operation front displacement, in terms of open-pits it is proposed to apply following scheme (Fig. 5) of layer-by-layer mining and biological reclamation aimed at restoring of natural landscape and providing water exchange processes.

ISSN 1607-4556 (Print), ISSN 2309-6004 (Online) Геотехнічна механіка. 2017. №132



a) natural; b) man-made; в) man-made geological environment with the restored properties (according to M.S. Chetverik and O.A. Voron)

Figure 4 – Technique of layer-by-layer mining and biological reclamation



1 – mineral; 2 – seat clay; 3 – sand; 4 – hydraulic excavator; 5 – man-made mass of joining with natural environment; 6 – area of man-made ravine formation; 7 – water-bearing level; 8,9,10 – first, second, and third layers of planting, correspondently; 11 – capillary water

Figure 5 – Scheme of layer-by-layer mining and biological reclamation

The essence of the proposed technological scheme of layer-by-layer mining and biological reclamation of the open-pit area is as follows: mining of levels involves the formation of inner mine dump with horizontal rock layers to develop capillary system. When the planning of the area surface to be reclamated is completed, man-made ravine is formed as the artificial structure allowing restoring the relief and water exchange processes within the disturbed natural environment. After that, grain and legume crops are planted within the layers of potentially fertile soils in terms of incline layer formation to develop the structure of soils; it is required for further supply of water-bearing levels of surface rivers as well as for restoration of surface discharges to accumulate atmospheric precipitations to supply the rivers with water.

In this case, the formed man-made ravine acts as a mine dump with no additional expenditures for reclamation as they are included into the prime cost of overburden operations and dump formation. However, depending on the direction of mining operation front, the represented scheme may vary.

Consequently, while forming man-made relief it is expedient to set the goal of developing the system of hollows and ravines that will make it possible to improve water exchange processes and supplying plants with water in general.

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Анотація. В статті розглянуто сучасні способи відновлення ландшафту і водообмінних процесів у порушеному геологічному середовищі в процесі відвалоутворення і рекультивації при відкритій розробці горизонтальних і пологопадаючих родовищ. Встановлені взаємозв'язки між напрямками переміщення фронту гірничих робіт кар'єру і потоком поверхневих і підземних вод, їх вплив на ефективність технологічних процесів відкритої розробки. Визначено раціональний напрямок переміщення фронту гірничих робіт, що дозволяє відновити рельєф поверхні у вигляді, близьким до природного. Приведено схему пошарової гірничотехнічної та біологічної рекультивації порушених земель для подальшого використання їх у сільському господарстві.

Ключові слова: відкрита розробка, напрямок переміщення фронту гірничих робіт, внутрішній відвал, порушене геологічне середовище, рекультивація, відновлення ландшафту.

Аннотация. В статье рассмотрены современные способы восстановления ландшафта и водообменных процессов в нарушенной геологической среде в процессе отвалообразования и рекультивации при открытой разработке горизонтальных и пологопадающих месторождений. Установлены взаимосвязи между направлениями перемещения фронта горных работ карьера и потоком поверхностных и подземных вод, их влияние на эффективность технологических процессов открытой разработки. Определено рациональное направление перемещения фронта горных работ, которое позволяет восстановить рельеф поверхности в виде, близким к природному. Приведена схема послойной горнотехнической и биологической рекультивации нарушенных земель для дальнейшего использования их в сельском хозяйстве.

Ключевые слова: открытая разработка, направление перемещение фронта горных работ, внутренний отвал, нарушенная геологическая среда, рекультивация, восстановление ландшафта.

Стаття поступила до редакції 20.03.2017
Рекомендовано до друку д-ром технічних наук Четвериком М.С.