Use of overburden and enclosing formations generated in the course of exploitation of mineral deposits

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Abstract. This paper discusses one of today’s pressing challenges – conversion of mining and processing works waste into commercial products. The authors analyze the existing state of this issue in Sverdlovsk Oblast. The waste types are classified according to their sources and accumulation scopes. The waste is analysed for heavy metal content. It is established that mining and processing works waste are “man-made mineral deposits”. The paper introduces an approach to conversion of industrial waste into secondary material resources. The purpose of this paper is to solve a set of tasks characterized by catastrophic environmental damage due to pollution, mainly by mining and metal industries. Environmental risk is minimized, an interface with metal recycling is established, and the RF mineral resources base is expanded.

1. Introduction

Artificial, or man-made, soils are generated in the course of various human endeavours. About 80 % of the total man-made soil volume are soils generated in the course of mining engineering activities. As of now, over 8.5 billion tons of man-made mineral deposits have accumulated in the Ural Region and the area of disturbed land and dumping plots exceeds 200 thous. ha. Moreover, the major part of man-made accumulations is not recovered. The current legislation allows determining the possibility of their recovery and reusing either as man-made deposits of secondary resources by extraction of commercial components contained in them and as raw materials for construction, or as man-made accumulations of secondary resources by way of renovation or rehabilitation of territories occupied by them.

2. Reference and methodology

The paper uses the systems approach which is developed by abstract-logical, geographic, morphological and cartometry, as well as retrospective methods. The paper is based on the results of field investigations and analysis of numerous documents, graphic maps, and Earth remote sensing data.
3. Results and discussion

Exploitation of mineral deposits (hereinafter – MD) involves physical impact on natural rocks comprising rock masses enclosing the minerals. Such impact results in the separation of rocks and minerals from the rock mass and transportation of generated mined bulk as overburden to a dumping plot (waste heap) and of ore mass to facilities for further beneficiation and (or) extraction of commercial components. The general case of mined bulk movement balance suggested by the authors under mining and land allotments within the period of MD exploitation is shown in Figure 1.

![Figure 1](image-url)  
**Figure 1.** Mined bulk movement balance  
A – mineral extraction, B – overburden accommodation by mining facility (dumping plots, waste heaps), C – primary mineral processing (beneficiation plant complex); Mb – mined bulk: I – Mb consumption by the facility, including the removed topsoil and vegetation cover, II – overburden dumping; III – beneficiation plant waste, IV – end product (concentrate, etc.).

In this case overburden means rocks covering and enclosing minerals, subject to extraction and movement as dump ground in the course of mining operations [1]. Over-burden can be hard (solid rocks or semi-rocky soil), cohesive and loose [2]; in fact, after dumping they all are broken mine rocks. There are two types of dumping plots (waste heaps): piled and washed-in, different in the method of construction and design. As for the method of MD exploitation, open mining implies mainly piled dumping plots for covering rocky or semi-rocky soils (Figure 2) or washed-in hydraulic mine-dumps; underground mining implies piled waste heaps of enclosing rocky or semi-rocky soils (Figure 3); placer mining implies fine-grained tailings dumps or washed-in dumping plots for covering cohesive or loose rocks (Figure 4). Mining waste (washery refuse, products of atmospheric emissions and effluents of mine and industrial waters, and other mining waste) shall be placed on piled dumpling plots or liquid waste ponds (slurry and tailing pits, sedimentation ponds, etc.) (Figure 5).

![Figure 2](image-url)  
**Figure 2.** Quarries of Anatolievsksiy Mining and Processing Works (Novoasbest, Sverdlovsk Oblast).
Accumulation facilities for overburden and waste require separate accommodation within the mining complex (hereinafter – MC). A part of man-made accumulations is recovered in the process of MD exploitation, while another part of them stays at MC where such accumulations are stored, preserved or subject to burial ground dispersion.

Man-made accumulations left after MD exploitation are of particular concern. Thus, total area of dumping plots (waste heaps) of depleted quarries (mines and ore pits) in the Ural Region amounts to approximately 17.6 thous. ha, while the areas of placer mining dumping plots (fine-grained tailings dumps) can be estimated through the following examples: the area of a 13.6 km long depleted platinum field along the river Lobva (Kytlym village) is 730 ha, that of a 33.8 km long depleted gold field along the river Is from Shumikha village to Is village is 7140 ha, that of a 15.8 km long portion along the river Neyva from Serbishino village to Nevyansk town is 680 ha, taking into account the fact that in the XIX-XX centuries placer mining had been conducted on over 250 small and medium rivers.
Thus, for example, within Nizhny Tagil city (Sverdlovsk Oblast) there are slag dumps comprised of blast-furnace and steel-making slag rejects. Both dumping plots are operating since 1949. Today they contain over 60 million tons of waste. These dumping plots are basically man-made deposits of ferrous and non-ferrous metals. As compared with the corresponding bulk earth values in the lithosphere, the content of the following elements in the dumping plot is particularly high: vanadium (111 times the lithospheric value), chromium (60 times), manganese (14 times), cobalt (8 times) [12-20].

Another example can be considered: bottom sediments of Lake Karabash (Chelyabinsk Oblast) with its ecological state being affected by an iron and steel plant. The full-penetration analysis of bottom sediments has shown the following content of elements (mg/kg): copper – 3384, zinc – 2417, manganese – 4443. In summary, bottom sediments are man-made mineral deposits the content of metal in which is estimated as commercial reserves.

4. Conclusion

Disputability of overburden and enclosing rocks categorization as production waste [3] is discussed in the relevant article [4] fully enough. However, if waste, including overburden, can be utilized, it may be classified as raw materials, supplies or products, meaning that waste can be shifted to this status if there is a demand for it. In this case overburden and enclosing rocks, as well as beneficiation and other mining waste as per GOST R 54098-2010 [5], can be shifted to the category of secondary material resources.

Such categorization of overburden and enclosing rocks, as well as beneficiation waste, requires no license related to their movement, storage, and disposal; their further use only requires an approval of the State Environmental Expert Review for new machinery, technology, and materials [6], provided that company standards and waste management specifications are approved [7].

During MD exploitation, all this is done by the subsoil user who is the owner of the generated products (waste) according to art. 136 of the Civil Code of the Russian Federation; among other things, the owner can deprive of its products.

After MD depletion, i.e. after MC facilities retirement, the remaining secondary material resources are divided in the following way: According to the current legislation [8], the subsoil user must get consent and approval for the standard content of minerals remaining in overburden and enclosing (diluting) rocks, on dumping plots or in mining and processing works waste. If the conditions are fit for utilization in terms of any type of commercial components, such facilities are shifted to the category of man-made deposits of secondary resources [5] and recognized as state mineral reserves [9]. In this case monitoring and storage of such facilities are arranged by the State.

Otherwise, the remaining facilities are categorized as man-made accumulations of secondary resources, which implies their economic use in near or far future as secondary material resources. They can be directly used by their owner unless the latter deprived of them. In case of deprivation, the facilities gain the status of res nullius [10]. To be able to use them, firstly it is required to determine their hazardous level and estimate the past environmental damage accumulated within the territory of the mining works.

If the facility is deemed safe, i.e. is not subject to preservation or liquidation, it shall be included in the state cadastral register and the local government shall register its right for such facility. If the facility cannot be identified as a real estate item, i.e. the facility is a dumping plot, a land plot shall be created for it and included in the state cadastral register with similar registration of the rights for such facility. After that, the facility may be reclaimed or renovated, possibly with the involvement of external investors.

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