Applied Mineralogy of Mining Industrial Wastes

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Abstract. Recycling and disposal of mining wastes has been very important and considered as an independent task. Features of composition and structure of mining wastes, identified by a set of mineralogical analysis methods, allowed predicting their possible involvement in the secondary processing. This was illustrated by the example of metallurgical iron slags.

Keywords: Mining wastes · Technological mineralogy · Iron slags

1 Introduction

The intense development of the mineral resource complex inevitably leads to accumulation of significant amounts of waste, which negatively affect natural ecosystems. Therefore, the disposal and recycling of wastes is important at the national level and considered within framework of the priority direction of development of science and technology in the Russian Federation – “Rational environmental management”. Today we can state the fact that recycling is an independent major task for our industry.

Mining and processing wastes are very diverse. They include overburden, host rocks, dry raw processing, off-balance sheet and non-standard ores, which composition and properties are not only close to their natural analogues, but usually used the same way. Processing wastes of metallurgical, chemical, heat power industries are more abundant. Slags, muds, ash slags and oil muds, burnt rocks, pyrite cinders, clinkers, dusts are significantly different from natural ores and rocks. They are characterized by variable granular composition, often a high dispersion, presence of amorphous formations, complex interrelationship of mineral and (or) technogenic phases, including presence of eutectic colonies or structures of decomposition of solid solutions, a small amount of one or more minerals, polymineral (polyphase) aggregates, presence of isomorphic minerals and polytypic modifications, secondary changes associated mainly with hypergenesis.

2 Methods and Approaches

The study of the composition, structure and technological properties of mining wastes is based on modern scientific, methodological, technical and instrumental support for the researches of technogenic raw and allows predicting its possible involvement in secondary processing, including elimination of environmental consequences of industrial processing (Ozhogina et al. 2018; Ozhogina et al. 2017; Chanturia et al. 2016; Yakushina et al. 2015; Ozhogina and Kotova 2019; Burtsev et al. 2018). Necessary and sufficient mineralogical information about the object is possible to get by a complex of mineralogical and analytical methods (optical and electron microscopy, X-ray, X-ray tomography, micro X-ray spectral analysis). For different types of wastes, an individual set of mineralogical analysis methods is used, which allows to obtain complete and reliable information, including information on the phase composition of technogenic formations, as well as the form of finding useful elements, granular composition, morphometric parameters, nature of localization of specific phases (Ozhogina et al. 2017).

Mineralogical study of mining wastes is carried out mainly according to the methodological documents developed for the analysis of natural mineral raw. Special methods of mineralogical analysis of industrial wastes do not exist. The study of such objects is of an interdisciplinary nature because of a reasonable combination of methods from various fields of science and adapted to solving mineralogical, technological and environmental problems.

3 Results and Discussion

The bulk of the processing wastes are slags. For example, iron-containing metallurgical slag is a loose material with dense lumpy aggregates and few octahedral crystals. More than 80% of the slag is represented by a thin material with a particle size of less than 0.2 mm. The main beneficial elements are iron (42.5%) and chromium (3.15%), which form their own mineral phases. Nickel (0.4%), associated with trevorite, and cobalt (0.08%), with unknown occurrence form, can possess industrial value.

A significant part of the slags (more than 75%) is formed by black magnetic material prone to artificial segregation, represented by spinelides forming a continuous isomorphic series spinel-magnetite-chromite. The main mineral is magnetite, which isolations are always non-uniform and contain numerous inclusions of non-metallic phases represented by olivine, pyroxene, mica, corundum, feldspar and glass (Fig. 1a). Sometimes the grains are surrounded by a fairly flat border of iron hydroxides and contain veinlets that do not extend beyond their boundaries (Fig. 1b). Two varieties of magnetite are noted; eutectic colonies are evidence of their simultaneous presence. This may be due not only to the closest intergrowth of the phases, or the oxidation process of a magnet and its partial transition to maghemite, but also continuous isomorphic substitutions of the ferrosinels, including heterogeneous -2 and 3 valence cations.

Fig. 1. A. Magnetite (light gray) with inclusions of non-metallic minerals, in the center of the grain is maghemite (white). B. Magnetite (light gray) with veins and border of iron hydroxides. Polished thin section, nicols are parallel

The features of the mineral composition and structure of iron-containing slags (phase composition, distribution of ore phases and aggregates, their morphostructural characteristics, heterogeneous structure of magnetite), identified by a complex of mineralogical analysis methods, suggest the expediency of chemical processing methods at recycling (Yakushina et al. 2015).

4 Conclusions

Mining wastes, being main types of technogenic raw, possess mineralogical characteristics (mineral and (or) phase composition, useful component occurrence form, morphostructural features and distribution pattern, real composition and structure) that determine the strategy and tactics of its secondary use:

- (1) as initial raw without processing, for example, for extraction of valuable metals;
- (2) as initial raw after additional processing to obtain material resources in the industry.
- (3) as object of disposal.

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