New methods of processing of Cuban nickel ores and technogenic slimes

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Abstract. In this paper the problems of beneficiation of lateritic nickel ores of the Cuba Republic and passing extraction from them and slurry waste of elements of platinum group is discussed. For carrying out research 100 kg of ore and 130 kg of tails of beneficiation were selected. It is established that in the course of receiving nickel-cobalt go of a sinter in slimes concentrates rhodium (0,074 %) and platinum (0,018 %). The chemical composition of the ore is now determined at the specialized pilot processing research center in Cuba on eight elements only (Ni, Co, Si, Fe, Mg, Al, Cr), but rare and PGM metals content is not included in the assessment scope. Within the scope of science and engineering cooperation between the Mining University (St. Petersburg) and the Higher Institute of Mining and Metallurgy, Moa a dressability assessment of laterite ores involving recovery of other rare earth metals (REM) has been performed. The investigation of the performance data available allowed to arrive at a conclusion that the most expedient means of production cost reduction to make it competitive with no capital reconstruction of metallurgical shops will be a pre-concentration process.

Cuban lateritic nickel resources are formed when peridotite, an igneous rock comprising predominantly the mineral olivine, which contains around 0.25-0.30% Ni, are exposed to prolonged and intense chemical weathering. During such prolonged weathering, the magnesium and silica are leached out of the rock to leave a residue rich in ferric oxide, nickel and other minor constituents such as aluminum and chromium. Lateritic nickel deposits are classified on the basis of differences in the essential make-up of the profiles. The differences between limonitic and silicate minerals influence the methods by which they are treated for nickel recovery [1].

Republic of Cuba has considerable world reserves of oxide nickel ores with diagnostically proven content of platinum metals, permitting to consider by product concentration of platinum metals and rare earth metals (REM) economically feasible in nickel production [2,3]. Cuban metallurgical industry ranks among the countries with the largest nickel ores deposits and the world leaders in nickel production. Cuban nickel ores and concentrates are characterized, and the ore processing technologies are described. Total platinum metals grade of the most commonly encountered oxide iron-nickel ores in Cuba is 0.20-0.32 gr/t on the average.

In new view of the inevitable loss of platinum metals during the metallurgical processing of initial ores and the deterioration of the quality of ore raw materials, along with a decrease in the share of platinum mining from other placers there is a need to look for new non-traditional sources of platinum group metals. At now there are the confirmed world reserves of nickel make 65 billion tons. The Republic of Cuba is among the largest countries on this indicator [4,5], and nickel reserves on the island
are estimated at 5.8 million tons. Laterite nickel - cobalt ores are in the territory of the national reserve with a small depth to 6-12 meters. Laterite ores share on limonite and serpentine. These are mainly ferrous ores with the high content of nickel (from 1.4 to 3.4% and more) and the most part of the Cuban enterprises which carry out their repartition are focused on production only nickel cobalt concentrate.

The Cuban enterprises of Ernesto Che Guevara is the largest metallurgical which project was developed and realized by the Russian experts. Within scientific and technical collaboration Mining University (St. Petersburg) and the High mining and metallurgical institute (VGMI, Cuba) represented scientific and technical interest to investigate lateritic ores preparation at control of the content of platinum metals.

In this paper the problem of enrichment of lateritic nickel ores of the Cuba Republic and passing extraction from them and slurry waste of elements of platinum group is discussed. For carrying out research 100 kg of ore and 130 kg of tails of beneficiation were selected. It is established that in the course of receiving nickel-cobalt go of a sinter in slimes concentrates rhodium (0.074 %) and platinum (0.018 %). The chemical composition of the ore is now determined at the specialized pilot processing research center in Cuba on eight elements only (Ni, Co, Si, Fe, Mg, Al, Cr), but rare and PGM metals content is not included in the assessment scope. Within the scope of science and engineering cooperation between the Mining University (St. Petersburg) and the Higher Institute of Mining and Metallurgy, Moa a dressability assessment of laterite ores involving recovery of other rare earth metals (REM) has been performed. The investigation of the performance data available allowed to arrive at a conclusion that the most expedient means of production cost reduction to make it competitive with no capital reconstruction of metallurgical shops will be a pre-concentration process. Control of a chemical content of ore exercised only for 8 elements (Ni, Co, Si, Fe, Mg, Al, Mn, Cr) in specialized technological scientific center [6]. The content of rare metals and metals of platinum group isn't defined. The high content of chrome in ore (contents of nickel and cobalt are higher) and transition at magnetic separation to magnetic fraction indicates expediency of its individual extraction on the separate technological line.

Laboratory research of the selected samples of nickel ore on pilot installations can reveal character and kinetics of concentrating of metals of platinum group in semi-products at all technological stages. The magnetic product produced at the beneficiation stage is subjected to hydrometallurgical processing by the method of reductive sulfuric acid leaching to produce rich platinum metal concentrate. Prevalence of the content of iron confirms on expediency refining of the oxidize nickel ore by hydrometallurgical process or applications of technology Fe-Ni production.

At the first stage carried out gravitational processing of nickel ore and the granulomere analysis. The site analysis of 1 kg of the crushed ore was carried out by a standard technique. In order to separate was applied grids with diameter of 1.2; 0.75; 0.45; 0.35; 0.25; 0.15; 0.075; 0.035 mm. Results of the size analysis in cumulative dependence \( \sum y(%) = f(\log d) \) are given in Figure 1.

![Figure 1. Results of the granulometric analysis.](image_url)
The analysis of technological conditions of nickel enterprise revealed that the main problems are:

- decreasing of the content of nickel in primary ore;
- considerable emissions of dust and gases on a site of drying and roasting of a nickel concentrate;
- imperfect control of structure of a cobalt concentrate and production wastes;
- limited volume of slurry storages.

The analysis of technical data revealed that in the real way which will provide decrease in product cost to competitive level and won't demand capital reconstruction of metallurgical shops are preliminary processing ore before carry out technological operation [7-9].

It is noted should that the main losses of nickel components produce at preparation of ore in time of preheating because of drying and calcination are made on outdated technologies by using many floors furnaces. Serves it as the proof is that during preliminary calcination of the selected samples of nickel ore in the laboratory of Mining university in the boiling layer furnace was found osmium (0,013-0,019 %).

At the following stage we carry out research of the oxidized nickel ore on the X-ray fluorescent analyzer. Calculation is executed by means of a method of Fundamental Parameters and quantitative analysis without using of standard models of comparison (Figure 2).

![Figure 2](image.png)

**Figure 2.** A range of a sample of the oxidized nickel ore with noted peaks of Mg, Al, Si, S, Ca, Cr, Fe, Ni, Co, Mn, Cu and Zn.

The high content of chrome in ore (contents of nickel and cobalt are higher) and transition at magnetic separation to magnetic fraction indicates expediency of its individual extraction on the separate technological line. At classification of ore traces of platinum group aren't found but in small fractions presence of REM - osmium and rhodium are revealed. Most likely is that the main losses of these elements happen when preheating in the heating furnaces in time of first technological process.

Availability of osmium (REM) in not magnetic fraction indicates the need its extraction at initial stages of processing nickel ore (calcination stage).
Existence of traces of metals of platinum group in initial nickel ore (Pt - 0,002%) and increase in their content in slime (Pt - 0,03%) assumes their content during all production cycle that can be confirmed only after the analysis of semi-products (a cobalt concentrate or a sinter).

It was carried out classification oxidized ore and slime by method of magnetic separation (the sample was weight - 100 g) with various current loading [10]. The preliminary analysis of ore was revealed content Fe 78,4% in ore and 84,2% in technogenic slime.

After magnetic separation the main part is magnetic fraction and in slime tests this transition is more obvious. It can be assumed that the combination of gravitationally magnetic concentration methods and reductive sulfuric acid leaching of nickel ore makes it possible to produce standard platinum concentrate from sinter.

After magnetic separation of ore, the main part of magnetic fraction is iron and chrome. The most part of not magnetic fraction is made by aluminum and magnesium and from rare elements such as osmium traces are found. The high content of aluminum and other light metals in not magnetic fraction of ore can make attention of experts in the field of aluminum production.

After separation of slime in not magnetic fraction rhodium (0,069 %) and platinum (0,032%) was found after separation of slime in not magnetic fraction. It should be noted that platinum metals are found generally small fractions and dust. It allows made conclusion that at all technological stages production nickel and cobalt sinter concentrate metals of platinum group. Thus, their main part is in semi-products and other part will get to slurry waste. Availability of metals of platinum group at the intermediate stages of production indicates for us on expediency of their individual extraction by separating technological line.

Actual are researches on complex processing of the oxidized nickel ores (laterites) with use of modern resource-saving technologies at the maximum extraction of nickel and cobalt. In case of their positive result the Cuban nickel enterprises can turn into their main part is made by aluminum and magnesium and from rare elements such as technogenic slime. It can be assumed that the combination of gravitationally magnetic concentration methods and reductive sulfuric acid leaching of nickel ore makes it possible to produce standard platinum concentrate from sinter.

The Cuban metallurgical industry needs to be modernized to produce the final product in the form of ore, concentrate and dust. It allows made conclusion that at all technological stages production nickel and cobalt sinter concentrate metals of platinum group. Thus, their main part is made by aluminum and magnesium and from rare elements such as technogenic slime. It makes it possible to produce standard platinum concentrate from sinter.

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