

## DECREASING ORE GRADES IN GLOBAL METALLIC MINING, A THEORETICAL ISSUE OR A GLOBAL REALITY?

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Key Words: Energy use, mining industry, exergy, mineral resources.

Mining industry requires great amounts of energy to extract and process resources, including a variety of concentration and refining processes, which normally depend on the mineral extracted, the ore grade, economic issues and mining conditions, among other factors. Using energy consumption information, different sustainability issues can be addressed, such as the relationship with ore grade over the years, energy variations in electricity or fossil fuel use, etc. (Glaister & Mudd, 2010; Northey et al., 2013). Therefore, analyzing the energy intensity use in mining could lead to progress towards a better sustainable industry and a better resource management.

Numerous studies have focused on the energy consumption of mining projects, carrying out the analysis primarily in one single country or one single element (Mudd, 2007; Mudd, 2010). Nevertheless, the information obtained in this paper represents a new and more accurate approach. For the first time, the most important mines that extract economically important minerals from several countries have been studied. Mines that extract gold, copper, lead and zinc have been selected, trying to take into account those mining companies whose reports were more accurate and reliable. Data regarding ore mined and milled, contained mineral, average ore grade, energy use and waste rock has been compiled. Moreover, the evolution of the ore grade over the years has been analyzed for each mine as well as the dependency of the energy intensity according to the type of the mine and process. The relationship between declining ore grades, energy and production has also been studied.

After analyzing the energy intensity use as a function of the ore grade, the main conclusion that can be drawn is that as the ore grade decreases in the mine, the total energy consumption per tonne of ore seems to increase as well as the diesel and electricity used. Additionally, underground mines are more energy consuming than open cut mines, and the process of each mine also has a big influence in the energy consumption pattern. Still, ore grade seems to be one of the most important factors affecting the total energy consumption in the mining industry. With the case of copper, the study shows that the average copper ore grade decreases over time, while the energy consumption and the material produced increases. Analyzing Chilean copper mines, the average ore grade has decreased approximately 28.8% in just ten years. In the case of energy consumption in those mines, there is a 46% increase from 2003 to 2013, while the increase of copper produced for that same period is 30%. This seems to be in accordance with the historical trends observed for other mines at global level.

Decreasing ore grades is no longer a theoretical issue but a global reality caused by the increasing consumption of raw materials as demonstrated by the empirical and updated data presented here. It also entails increases in the amount of ore mined and energy intensity, enhancing environmental and social costs. As this is not a trivial matter, comprehensive studies should be carried out considering the scarcity of raw materials in the accounting systems to improve resource management and promote the sustainable use of natural resources.

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