Imperial College London

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2024_36_ESE_PB: Advanced imaging techniques to enhance energy efficiency in the processing of critical raw materials

Supervisors: Dr Pablo Brito-Parada (mailto:p.brito-parada@imperial.ac.uk); Prof. Stephen Neethling; Dr Luis Salinas-Farran

Department: Department of Earth Science and Engineering

The green energy transition relies on a supply of critical raw materials to obtain metals that are essential to renewable energy technologies. It is thus necessary to improve conventional mineral processing methods to minimise their environmental impact, as well as understanding the effect of the different process variables to optimise energy and water consumption.

One of the most energy intensive processes in mining is comminution. Its energetic efficiency is commonly below 10%; however, it is an essential process in the mining industry. Comminution is understood as the reduction in size of raw materials, which is crucial to obtain a specific particle size range that allows for subsequent processing in downstream steps. The performance of comminution systems is highly affected by the interactions between the solid particles, the elements used as charge to promote breakage and, in some cases, the liquid in the system. Furthermore, the subsequent flotation stage benefits greatly when particles present a high surface exposure, as this process works on the particle surface chemistry to separate the valuable metal from the gangue. Although, the impact of the comminution variables is commonly assessed either by using destructive methods or by analysing the final product of very long and complex processes that involve multiple middle stages. This makes it impossible to track and quantify the performance of the system at each stage of the process, relying mostly on empirical knowledge.

This project will combine novel experimental and characterization techniques in order to better understand the effect that different methods used to achieve particle size reduction have on the efficiency of the process and the properties of the resultant particles. In particular, this will be assessed for mineral ores not only in terms of the resulting size but also based on the extent of surface exposure of the mineral grains. With this, textural properties of the material, the comminution method used, the reduction in size, and the extent of liberation of valuable material can be linked to one another.

The use of X-ray micro tomography (micro-CT) will allow a 3D mapping of minerals in rocks before, during, and after comminution; this is not a trivial task requiring the development of bespoke sample holders and advanced image processing and data analysis techniques. These 3D mineral maps will allow us to accurately determine the mineral liberation that is obtained when treating ores of different mineral texture and with various methods to reduce the particle size.

Ultimately, this information will be used to tackle low efficiencies in comminution and flotation circuits, achieving a new understanding of this process both at the particle scale and the unit process scale that can inform strategies for substantial energy reduction in the process