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Towards developing an integrated geometallurgical modelling framework of the minerals beneficiation chain

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Minerals and metals are essential for modern life and their reliable and responsible supply is critical to maintain and develop a sustainable world. However, their extraction and beneficiation has significant negative environmental impacts such as the contamination of water, air and land resources with toxic by-products from their processing. There is growing pressure for the mining industry to improve on its environmental performance by adopting sustainability principles in minerals and metals production. This improved sustainability can be achieved by selecting and improving beneficiation methods and processes to produce minerals and metals with reduced environmental impacts. Further the beneficiation and upgrading of ores is determined by their inherent mineralogical properties: bulk mineralogy and texture (liberation and association), as well as the variability of these attributes. Most environmental impacts observed downstream of the beneficiation process can be traced back to the mineralogical properties of the ores. Better understanding of ore mineralogy and the mineralogical variability can also offer invaluable information for highlighting and mitigating potential environmental risks. Early integration of sustainability decisions into the design of the minerals beneficiation flowsheet offers greater potential for reducing environmental impacts at mining and processing sites. The objective of this study is to demonstrate how integration of sustainability indicators and mineralogical attributes can be achieved in minerals processing flowsheet modelling. A methodology for achieving this integration is proposed in this study.

An existing integrated mineral processing unit model that incorporates parameters that capture the effect of variation in process feed stream mineralogical attributes on model outputs, is developed to output sustainability indicators. The effect of ore variability on overall process performance indicators is determined and a set of potential environmental outputs is identified. A set of sustainability indicators that vary with changes in feed ore minerology is defined and rated, based on the model outputs. The obtained sustainability indicator ratings are inputted into a systematic decision analysis algorithm which gives a quantitative indication of the sustainability of processing a particular feed ore.

The results of the study show the dependence of overall sustainability rating on feed ore mineralogical attributes and highlight the importance of incorporating process stream

mineralogical attributes in integrating sustainability indicators in process unit model development. Using the integrated process unit modelling approach developed in this study for a single unit model it is proposed to develop an integrated geometallurgical process flowsheet modelling framework of the complete mineral beneficiation chain consisting of a number of unit models. This developed modelling framework will offer an enhanced methodology (tool) for better decision-making, leading to optimisation of the value and responsible stewardship of a mineral resource. Using this framework it will be possible to evaluate the technical and economic implications of new methods and processes up- and downstream of the intervention, as well as the environmental or social implications.