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Applied mineralogy for the responsible utilisation of natural resources

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To derive maximum benefit from our natural resources, a number of strategies can be implemented. An integral part of these involves applied mineralogy, which plays a key role in the established but evolving field of geometallurgy. Different, but interlinked areas of impact are important to note, all of which, to varying degrees, can be encompassed in a geometallurgical approach to the utilisation of natural resources.

Process efficiency is a key consideration, emphasised for ores of lower grade and higher complexity than previously encountered. Commodities of interest are increasingly found in difficult-to-extract minerals, for which traditional methods to upgrade and extract are no longer valid. Mineralogical information is thus increasingly necessary to guide and assess processing, which traditionally relied on assay data only. Coupled with this, is the need for more efficient use of other dwindling resources in processing, e.g. water, energy, and reagent consumption. These challenges call for novel characterisation approaches from the mineralogist, and the need to use the mineralogical information in more meaningful ways to predict and enhance process performance.

Environmental consequences pose challenges linked with process efficiency. In dealing with environmental issues emanating from inadequate planning/process efficiency, dump/tailings treatment strategies consider metal recovery that can pay for the clean-up of the environment post-mining. In the case of acid mine drainage (AMD) treatment, valuable metal recovery, neutralisation and recycling of contaminated water for industrial or potable uses are important outcomes. Urban waste recycling also examines how valuable metals can be recovered, again minimising the use of other resources like energy and water, and reducing further environmental impact. For ongoing or new ventures, environmental consequences can be predicted, and appropriate mitigation put in place. In all of these aspects, mineralogy has a significant role to play for the success of the processes employed, with adoption of characterisation approaches often more in the realm of the materials scientist.

An often-neglected area in applied mineralogy for resource enhancement involves socio-economic impact. A particular area of importance in the South African context is the small-scale mining sector, for which job creation and sustainability rely on education of rural communities on how best to mine and beneficiate natural resources – a different set of challenges to the formal mining industry, but one in which mineralogists must be involved. At the other end of the mining process, rehabilitation must prevent detrimental effects on the population and agriculture in the vicinity, and is thus also linked with environmental impact. Again, mineralogy plays a vital role in delineating affected areas and recommending rehabilitation strategies that help rural communities. In-between, legislative frameworks are increasingly requesting scientific input on provenance of commodities, as part of establishing certified trading chains that address conflict/theft for the well-being of society at large. Mineralogical approaches are key to these inputs.

Industry-driven process efficiencies must be considered together with environmental, socio-economic and sustainability challenges in developing holistic, and *responsible* strategies for natural resource utilisation. Innovative approaches through multidisciplinary efforts, and effective communication among these disciplines, are necessary for the success of these strategies. Applied mineralogy, as an integral part of these efforts, must continue to evolve to address these challenges and thus meaningfully contribute to the responsible utilisation of our natural resources.