2024_67_NHM_JW: Developing a chemical audit approach for characterisation of mine site material: implications for magmatic and hydrothermal transport, critical element recovery, environmental impacts and waste repurposing

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The aim of the project is to develop and test an analytical workflow that will enable integration of bulk and grain-scale analytical techniques to deliver a self-consistent chemical and mineralogical characterisation of mine site materials. This workflow aims to mineralogically and chemically characterise mine sample materials as completely as possible, particularly in terms of: (1) geochemical tracers of igneous and hydrothermal processes; (2) potential by-product elements and minerals that could be targets for recovery; (3) hazardous and deleterious elements/materials that could induce negative environmental and community impacts; and (4) contaminant elements that may impact economic viability of the repurposing of waste materials. We describe this approach as a chemical audit in which we aim to quantify, as far as possible, the mineralogy of the sample and the mineralogical residence of each element and its relative abundance in each mineral as a proportion of its total abundance in the complete sample. The resulting audit should be self-consistent in terms of bulk geochemistry, bulk mineralogy and mineral crystal-chemistry. This study will initially be applied to porphyry copper mineral systems but can ultimately be extended to any other kind of ore deposit type. A proof of concept study as part of a NERC-DoST (Philippines) PPD grant successfully demonstrated the principles of the approach which combines: (1) conventional 'complete characterisation' bulk rock sample analysis of ~60 major, minor and trace elements; (2) X-ray diffraction (XRD) and thermogravimetric analysis for bulk mineralogy; (3) mapping and quantification of grain-scale mineralogy using digital petrographic imaging and automated SEM mineral mapping; and (4) microanalysis of mineral compositions using scanning electron microscopy energy dispersive spectroscopy, electron probe microanalysis and laser ablation ICP-MS. Ultimately, bulk sample properties estimated from grain-scale analysis will be reconciled with the bulk, meso-scale analyses. The implications of the results for understanding igneous petrogenesis and hydrothermal transport, discrimination of fertile mineral systems, and the residence of critical and hazardous metals in rocks will be explored.