

Migration of transition metals and potential for mineral carbonation during acid leaching of kimberlite mine tailings

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Summary

Carbonation of mafic and ultramafic rocks and mineral wastes provides a permanent way to sequester excess atmospheric CO₂. Recent research has shown that this method also offers potential for transition metal recovery from mine tailings [1]. In this study, kimberlite tailings from Venetia mine (South Africa) were used for column acid leaching experiments to assess whether valuable base metals could be recovered during mineral carbonation. Tailings were treated daily with one pore volume of dilute HCl (0.04 M, 0.08 M, 0.12 M and 0.16 M) for 28 days.

The carbonation potential of the tailings and leachates, as well as the mobility of transition metals, were investigated with a combination of quantitative X-ray diffraction (XRD) using Rietveld refinements, inductively coupled plasma mass spectrometry (ICP-MS), scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDXS) and X-ray fluorescence microscopy (XFM) coupled with micro-X-ray absorption near edge structure (μ -XANES) analyses at the Cr K-edge and Ni K-edge.

Our results show that the high proportion of clay minerals (e.g., lizardite, smectites, talc, chlorite) in the tailings act as a source for Ca, Mg and transition metals such as Fe. The extraction rate of Mg and Ca increases with HCl concentration; however, calcite is the main source for Ca, decreasing the net CO₂ sequestration potential. Clay minerals provide Mg, accounting for an estimated CO₂ offset potential of 2-16% at Venetia. Release of transition metals from clay minerals decreases with depth in columns. Poorly crystalline and highly iron-rich yellow precipitates formed during the experiments both at the tops of the tailings columns and within the leachates. In particular, the yellow precipitates on top of the tailings are extremely rich in Si, which is consistent with leaching of metals from silicate minerals. The yellow precipitates that formed within the leachates have a higher Fe concentration and are richer in Fe-(hydr)oxides. Unlike Ca and Mg, which are mobilized into leachates, transition metals such as Ni are concentrated into the yellow precipitates at the tops of columns, providing guidance for future economic recovery.

[1] Hamilton, J. L. et al., 2018, International Journal of Greenhouse Gas Control, 71, 155–167.