

## **Predicting CO<sub>2</sub> mineralization in mine tailings: insights from leaching and geochemical modeling**

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Calcium and magnesium are released from weathering of ultramafic mine wastes, which facilitates the precipitation of secondary carbonate minerals that securely store CO<sub>2</sub> [1,2]. Previous estimates of CO<sub>2</sub> mineralization in mine tailings relied on extensive surveys and exhaustive sample analyses [2]. For widespread application, simplified methods of estimating CO<sub>2</sub> mineralization within mine wastes are necessary. We have developed a new tool for assessing the reactivity of mineralogically complex materials. We use CO<sub>2</sub> leaches coupled with total inorganic carbon (TIC) analyses to quantify the release of cations from both non-carbonate (desirable) and carbonate (undesirable) sources. Mineral feedstocks, including kimberlite residues from De Beers' Venetia mine in South Africa, were characterized (particle size, geochemistry, mineralogy, BET) and tested. A positive correlation between Mg and Si concentrations in leachates suggests a common silicate source. Conversely, Ca was mainly leached from primary calcite as indicated by a correlation with changes in TIC. Our tests show that CO<sub>2</sub> mineralization at the Venetia fine residues deposit has an average potential of 3,900 g CO<sub>2</sub>/m<sup>2</sup>/year or a 6% CO<sub>2</sub> emissions offset (13,500 t CO<sub>2</sub>e/yr). Furthermore, the misidentification of cation sources leads to an erroneous 8-fold overestimation of these rates. In conjunction with reactivity tests, CO<sub>2</sub> mineralization rates were estimated by mass balance calculations and inverse geochemical modeling (PhreeqC) using 12 years of Venetia water chemistry data. Our model suggest that 1,600–2,980 g of atmospheric CO<sub>2</sub>/m<sup>2</sup>/year is potentially stored in Venetia fine residues. These rates are lower but comparable to results obtained from reactivity tests and suggest that greater sequestration may be achieved through strategies that promote further silicate mineral dissolution. Our approach enables mining companies to easily assess the reactivity of their mine wastes with CO<sub>2</sub> and estimate mineralization rates using existing water chemistry data with the potential to claim carbon offsets.

[1] Power *et al.* (2014), *Minerals* 4, 399–436. [2] Wilson *et al.* (2011), *Environ. Sci. Technol.* 45, 7727–7736.