

Enhanced weathering and carbonation of kimberlite residues from South African mines

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Volcaniclastic kimberlite residues from diamond mines undergo rapid weathering, thereby sequestering atmospheric carbon dioxide (CO₂) [1-2]. Residues from the Venetia Diamond Mine in South Africa are a valuable feedstock with the potential to sequester four to seven times their carbon emissions. These mine wastes are fine-grained (<1 mm), have high surface areas (6.8–13.4 m²/g), and contain reactive mafic minerals including serpentine, diopside and clinocllore. Experiments utilized CO₂ flux chambers to directly measure the removal of atmospheric CO₂ within residues and mineral specimens. Residues dominated by massive volcaniclastic kimberlite gave a range of fluxes from -0.2 to 0 μmol/m²/s between 15–20% volumetric water content (VWC). Fresh pulverized dark volcaniclastic kimberlite exhibited a greater negative flux when VWC reached 15–18% at a rate of between -0.6 to -0.2 μmol/m²/s. Sediments composed of either 10 wt.% brucite [Mg(OH)₂] mixed with quartz sand or 100 wt.% forsterite [Mg₂SiO₄] were tested to compare a highly reactive hydroxide with a less reactive silicate. These sediments had maximum negative fluxes of -1.9 and -0.5 μmol/m²/s, respectively. Our experiments demonstrate that the mineralogical composition, surface area exposure, and water content of residues affect the CO₂ removal rate. Long-term weathering of kimberlite residues was explored using automated wet-dry cycles (4/day) over one year. Increases in the δ¹³C (+2.4‰) and δ¹⁸O (+2.2‰) values of carbonate minerals and increases in inorganic carbon indicate the storage of atmospheric CO₂. Unweathered and weathered kimberlite samples collected at Voorspoed Diamond Mine in South Africa was explored to further understand long-term weathering of volcaniclastic kimberlites via changes in mineralogical composition, inorganic carbon content, and stable carbon isotopic compositions. This research is contributing towards the utilization of kimberlite residues for sequestration of atmospheric CO₂ via enhanced weathering, a low cost and energy efficient strategy that makes use of waste pulverized rock.

[1] Mervine *et al.* (2018) *Miner. Petrol.* 112 (Suppl 2), S755–S765. [2] Wilson *et al.* (2011) *Environ. Sci. Technol.* 45, 7727–7736.