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An investigation of waste basalt (quarry dust) as a soil amendment to sequester atmospheric CO_2

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Results from new field and laboratory experiments to investigate the use of crushed basalt as a CO_2 sequestering soil amendment for removal of atmospheric CO_2will be presented. Unlike previous studies that envisage energy- and carbon-intensive mining, crushing and transport of mafic or ultramafic rocks for accelerated silicate weathering, our focus is on the use of an existing basaltic rock waste stream as a soil amendment to sequester CO_2 by chemical weathering. The material investigated is crusher waste ('quarry dust'), from the commercial Budore basalt quarry in Northern Ireland. Our approach utilizes existing infrastructure and expertise in the extractive and agricultural sectors and involves socially acceptable practices (land spreading of soil amendments). Grain size analysis of the crusher waste from Budore has revealed that $\sim$15% of the material has a grain size $<$63 microns, facilitating accelerated weathering when added to soils, without the need for additional crushing. The basaltic crusher waste was added to metre-scale experimental plots on a range of soil types in Ireland in early 2018, at a rate equivalent to 10 tonnes/hectare. Soil solutions were extracted using suction-cup lysimeters at regular (typically monthly) intervals from the amended as well as from adjacent non-amended plots that serve as controls. In most cases, the basalt-amended soils exhibited small but significant increases in soil-water pH (by 0.1 to 0.2 pH units) and an approximate doubling of soil-solution electrical conductivity (dissolved ion load). The concentrations of two divalent cations that have the potential to permanently sequester carbon as $CaCO_3$ and $MgCO_3$ in the oceans increased in the amended soil solutions over several months in the field experiments, almost doubling (5ppm relative to 2.5ppm for Mg, 11ppm relative to 6.4 ppm for Ca) relative to the control plots. Increases of a similar order of magnitude were observed for Sr, V and Ni in the soil solutions relative to controls, reflecting inputs to soil solutions from basalt weathering. Field experiments are ongoing to assess the longer term effects of the basalt amendment on soil-water $Ca^{2+}$and Mg^{2+}, soil pH and nutrient status. Batch weathering experiments on the same basalt-soil mixtures conducted in parallel with the field studies show strong dissolution of the basalt's constituent olivine, with moderate dissolution of plagioclase and some dissolution of augite and ilmenite after two months. Release of Mg^{2+}, and to a lesser extent Ca from the basalt in the laboratory weathering experiments is higher than predicted in a simple mixing model based on weathering data for the basalt and soils in isolation, likely due to the influence of organic acids and microbes in soils that accelerate weathering. The experimental results are encouraging for the use of crushed basalt waste as a soil amendment to sequester atmospheric $CO_2$and to buffer pH in acidic soils. The latter presents opportunities to use basaltic 'quarry dust' as a lime substitute which would directly reduce lime-derived CO_2 emissions from agricultural soils.