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An experimental study on the impacts of phosphate on enhanced weathering of wollastonite in agricultural soils

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Addition of silicate minerals to agricultural fields as soil amendments has been proposed to facilitate enhanced rock weathering and sequester CO_2 [1]. Prior experiments have indicated that wollastonite applied to fields captures CO_2 through weathering, while elevating soil pH and releasing calcium and silicon, improving health of soils and plants [2]. The rate and mechanisms of wollastonite weathering in agricultural soils are not fully understood. Phosphate has been shown to enhance wollastonite dissolution rates, with 30 µM PO_4^{3-} tripling the dissolution rate of wollastonite at 25 °C and neutral pH [3]. Phosphate-containing fertilizers are commonly applied to agricultural fields, resulting in elevated phosphate concentration in soil pore waters and runoff. To investigate the interactions between phosphate and wollastonite in agricultural soils, a set of column experiments was conducted.

Ten 30 mL columns were constructed, consisting of pure wollastonite, pure soil, and a soil-wollastonite mixture of 8:1. Half the columns were irrigated with de-ionized water, and the other half a 10^{-4} M K_3PO_4 solution. Column effluent was sampled for analysis of fluid composition over time. Solids were analyzed with depth by X-ray diffraction and scanning electron microscopy to assess the extent of wollastonite dissolution and identify possible secondary mineral precipitation. Preliminary results from analysis of effluent samples indicated that pH of effluent from columns irrigated with phosphate was elevated relative to those irrigated with water. Wollastonite dissolution tends to increase fluid pH, suggesting wollastonite dissolution may have been enhanced in the presence of phosphate. If pending analyses support this, it suggests that in fields where wollastonite soil amendments are applied, phosphate might lead to greater wollastonite weathering rates, coupled with a greater increase in soil pH. The net impact on CO_2 uptake remains under investigation, but the change in pH between columns indicates that uptake of CO_2 and saturation state of secondary minerals could be impacted by the addition of phosphate to wollastonite-amended agricultural soils.

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[2] Haque, Santos, and Chiang. (2020), International Journal of Greenhouse Gas Control 97, 103017.

[3] Pokrovsky et al. (2009), American Journal of Science 309, 731-772.