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Exploring the effects of mineral dust acidification on oxidative potential and limiting nutrient solubility

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Mineral dust aerosol particles are ubiquitous in the atmosphere; they contribute to more than half of the total atmospheric aerosol burden and have far-reaching impacts on biogeochemical cycles, air quality and Earth's radiative budget. Much of the impact of dust is linked to its mild alkalinity and metal content, which directly influence atmospheric reactivity. However, metals and other trace nutrients (TN), such as phosphorous, are largely insoluble in freshly emitted dust and exhibit limited bioavailability for ecosystems upon deposition. The same metals can induce considerable oxidative stress upon inhalation, but mostly if in soluble form. Previous studies have found that atmospheric processing and, in particular, acidification of dust (caused by reactions with sulfuric, nitric, hydrochloric and organic acids) can promote TN solubility and increase the adverse health effects of population exposure to dust. Atmospheric processing also influences dust hygroscopicity and cloud-forming ability, directly affecting Earth's radiative budget and deposition patterns.

Previous experiments investigating the effect of atmospheric processing on mineral dust properties were mainly conducted in bulk materials and samples. The dissolution kinetics of metals and TN remains poorly constrained under real atmospheric conditions. To address this issue, we have developed an atmospheric simulation chamber facility where mineral dust particles from a wide range of soils can be generated and aged by any mechanisms relevant to the atmosphere (e.g., acidification through photooxidation and/or nocturnal chemistry).

This study provides a detailed characterization of the chamber facility and explores how acidification alters the properties of mineral dust. In particular, we examine the effect of nitrate and sulfate aging on the solubility of TN and the oxidative potential (measured with a DTT assay)

of the dust, under atmospherically relevant conditions. We conclude by relating these findings to field observations and discussing the implications for biogeochemical cycles and air quality.