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Diatom Extraction of Si from Silicate Minerals and Coupled Si-C Fixation

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Diatom growth occurs widely in freshwater and marine environments and accordingly has been studied extensively in aquatic habitats. In contrast, less is known of diatom-mineral interactions despite the organism's known presence in terrestrial settings such as soils and woodland. Because diatoms use silica to build their cell walls (frustules), we hypothesize that diatoms in soils may break down silicate minerals to extract Si and ultimately contribute to the coupled C-Si geochemical cycling. To test this hypothesis, we conducted laboratory studies of diatoms growth under silicon stressed conditions to investigate the dissolution process of olivine and potassium feldspar. Experimental results showed the presence of minerals led to a 5- to 10-fold increase in diatom biomass (more for olivine than for feldspar) while both minerals experienced significantly enhanced weathering presumably resultant from microbial activities for stress release. Further study suggests the biological mechanism of the diatom-mineral interaction is likely related to silicon stress triggering an up-regulation of silicon transporter expression. At the same time, transcriptomic analyses indicated that the diatoms changed the secretion strategy by up-regulating a large number of transcripts for the synthesis of metabolites containing carboxylic acid groups. Additionally, FT-ICR MS showed the exo-metabolites tend to have larger macular weights and higher degree of unsaturation. These results indicate the bio-weathering triggered by diatom growth likely remains to be chiefly proton- and ligand-promoted mineral surface reactions.

It is estimated that diatom frustules contain 80-90% silica and 5-20% organic material, suggesting the formation of frustules is in fact a coupled Si and C fixation process. Based upon the Si/C ratio of our experimental frustules and the lab grown diatom biomass estimated from Chlorophyll *a*, we attempted to compute the total amount of C locked in frustules through diatom photosynthesis, and the result comes to be around 10^{12} mol C yr^{-1}, approximately equivalent to one thousandth of the total annual global carbon emission at present.