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Magnesium isotope fractionation during granite weathering as an index of CO_2 consumption

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Granite weathering at the Earth's surface is an important control of mass and element cycling, continental weathering fluxes, and global carbon budgets. Magnesium and its isotope fractionation during weathering serve as a potential tool for tracking the above processes. In this study, we present Mg and isotopic data for bulk saprolites and constituent minerals from a 40 m depth granite weathering profile in South China, intending to elucidate the behaviors of Mg and Mg isotopes as well as to estimate the weathering fluxes and CO_2 consumption during chemical weathering. The majority of bulk saprolites exhibit negative $\tau_{Mg,Ti}$ values (ranging from -52.8% to 1.8%), with $\delta^{26}Mg$ values spanning from -0.24‰ to +0.15‰. Significant Mg isotope fractionation occurs during the formation of secondary minerals, with the lowest $\delta^{26}Mg$ values in illite and the highest values in kaolinite. The $\delta^{26}Mg$ values of both bulk saprolite and constituent minerals are influenced by pH values, with light Mg isotopes preferentially released into the soil solution under basic and weakly acidic environments and heavy Mg isotopes released into the liquid phase under acidic conditions. Using a mass balance model based on the weathering profiles, we propose a method to estimate weathering fluxes and CO_2 consumption during granite weathering. The results show that Mg elemental fluxes (Mg_{Flux}) range from 0.45 to 0.89 mol/cm^2/Myr; Mg isotope fluxes ($\delta^{26}Mg_{Flux}$) vary from -0.07 to -0.02 ‰/mol/cm^2/Myr, and CO_2 consumption (F_{CO2}) by granite weathering is 1.9×10^{12} mol/yr. These results indicate significant contributions of granite weathering to the global carbon sink of silicate weathering, capturing a substantial amount of atmospheric CO_2. The CO_2 sequestration by granite weathering is comparable in magnitude to that of basalt weathering over long time geological scales.