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The role of marine silicate weathering in regulating marine carbon cycle over geological time scales

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Weathering of silicates coupled to carbonate formation (i.e. Urey reaction) has been shown as one of the most important processes regulating atmospheric CO_2 through time:

reactive silicates + H_2O + CO_2 → *clay* + *carbonate* + H_4SiO_4 *Eq.1*

While terrestrial silicate weathering has been much studied and quantified, it is only recently that its marine counterpart has begun to receive attentions. Estimates of CO_2 consumption rates through marine silicate weathering using lithogenic silicates (0.3 to 3.2 Tmol C/year, Jeandel and Oelkers, 2015; 1-4 Tmol C/yr, Torres et al., 2020) are comparable with the net CO_2 consumption proposed for oceanic crust alteration (1.5-2.4 Tmol C/yr; Alt and Teagle, 1999). If we naively assume that all the silicic acid produced through CO_2 consumption via Eq. 1 is released to the oceans, marine silicate weathering, including both oceanic crust and lithogenic silicates, could supply the oceans with as much Si as rivers do (6.33 Tmol Si/yr; Sutton et al., 2018). In this study, we aim to examine the role of marine silicate weathering in the modern and past Si budgets by using the radiogenic strontium ratios ($^{87}Sr/^{86}Sr$) and stable strontium isotopic signatures ($d^{88}Sr$) from locations where dissolution of lithogenic silicates and volcanic glass has been shown to drive authigenic carbonate precipitation. The $^{87}Sr/^{86}Sr$ ratios reflect decomposition of either the ^{87}Sr-rich lithogenic silicates or the ^{87}Sr-poor volcanic aluminosilicates, without complications associated with carbonate precipitation or microbial processes. In contrast, the $\delta^{88}Sr$ signatures are fractionated during carbonate precipitation and thus provide a good constraint for the process. By simulating the pore fluid strontium & silica concentrations, as well as $^{87}Sr/^{86}Sr$ and $\delta^{88}Sr$ porewater profiles with a transport-reaction model, we show that silicate alteration and the accompanying carbonate precipitation could be active in sediments that are millions of years old and as deep as a few hundred meters below seafloor. Our results emphasize the role of marine silicate weathering as a substantial CO_2 sink over the long geological time scales.