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Potassium isotope evidence for enhanced reverse weathering in the Cretaceous ocean

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Reverse weathering, also known as marine authigenic clay mineral formation, has been proposed as an essential process that works in tandem with silicate weathering in maintaining the long-term stability of Earth's climate [1]. Reconstructing the magnitude of reverse weathering through time, however, has been challenging and controversial. The stable potassium isotope composition ($^{41}K/^{39}K$ or $\delta^{41}K$) of seawater has unique bearing on this topic because K primarily resides in silicates and its marine cycle is predominantly controlled by silicate weathering and clay mineral formation. Recent studies have suggested that modern seawater $\delta^{41}K$ is strongly influenced by reverse weathering [2], meaning that the reconstruction of seawater $\delta^{41}K$ in ancient oceans can provide novel information on reverse weathering processes and their relationship to the long-term carbon and silica cycle.

However, such reconstructions are challenging due to the absence of knowledge about suitable sedimentary archives that can preserve pristine seawater $\delta^{41}K$. Here we report the first $\delta^{41}K$ data set of recent and Cretaceous marine authigenic clay minerals, specifically glauconite. Glauconite grains were separated from recent marine sediments from two locations of different depositional settings, including ODP Site 959 in the equatorial Atlantic and the NE Pacific Oregon margin. Samples from the two sites show similar $\delta^{41}K$ values of -0.8‰ (0.1‰), defining largely constant fractionation from seawater $\delta^{41}K$ by ~0.95‰. These results indicate that marine authigenic glauconites are promising archives for seawater $\delta^{41}K$. Intriguingly, glauconite grains from a well-characterized Cretaceous marine sequence from Langenstein (Northern German basin) [3], as well as coeval GLO glauconite grains from Normandy (France), have similar $\delta^{41}K$ values (-0.67‰ 0.04‰) that are higher than recent glauconites. We interpret these results to reflect a purported higher $\delta^{41}K$ signature of Cretaceous seawater compared to today, likely due to enhanced reverse weathering in the ocean during the warm Cretaceous period.

[1] Baldermann, A. et al., Clay Minerals (invited review), under review; [2] Zheng et al., EPSL, 2022; [3] Baldermann, A. et al., Nature Comm., 2022