

Cation exchange controls seasonal river magnesium isotope variations in the upper Min Jiang, Tibet Plateau

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Chemical weathering plays a crucial role in regulating the global carbon cycle by consuming atmospheric CO₂, thus maintaining Earth's long-term habitability. However, its response to extreme events and climate change remains unclear, lacking robust tracing methods. Magnesium (Mg) isotopes, sensitive to primary mineral dissolution, offer potential for tracing catchment erosion and chemical weathering. This study investigates the temporal variations of riverine Mg isotopes ($\delta^{26}\text{Mg}$) at the Zhenjiangguan hydrological station in the upper Min Jiang, northeast Tibetan Plateau, with high-resolution weekly sampling to minimize uncertainties from spatial and lithological variations and directly assess the response of chemical weathering to extreme erosion and climatic factors (e.g., temperature, rainfall). Results show a systematic seasonal variation in riverine $\delta^{26}\text{Mg}$ (0.2‰ amplitude), ranging from -1.20‰ in the non-monsoon period to -1.00‰ during the monsoon, with rapid increases during six storm events. The riverine $\delta^{26}\text{Mg}$ correlates positively with suspended sediment concentration (SSC) and physical erosion rate (PER) ($r^2 = 0.56$ and 0.64 , respectively), suggesting preferential partitioning of light Mg isotopes into solids, thus enriching riverine $\delta^{26}\text{Mg}$. Excluding secondary clay and carbonate mineral formation, modeling and mineralogical analyses indicate that cation exchange adsorption of ^{24}Mg is responsible, particularly during storm events in the monsoon season, which create ion exchange pools that significantly elevate riverine $\delta^{26}\text{Mg}$. This study demonstrates that seasonal variations in riverine Mg isotopes in the upper Min Jiang are controlled by monsoon hydrology, providing field evidence for cation exchange regulation of riverine Mg isotopes under extreme erosion and global Mg cycling.