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Lithium isotopic evidence of continental silicate weathering evolution in late Quaternary Arctic marine sediments

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Continental silicate weathering represents a critical process in maintaining Earth's carbon cycle balance and planetary habitability. Current research on continental weathering has concentrated on low-latitude tropical regions, while the characteristics and mechanisms of weathering in high-latitude regions remain poorly understood. The lithium (Li) isotopic composition of clay-sized silicate particles in sediments reflects clay mineral formation during chemical weathering. Residual weathering products, primarily clay minerals, tend to preferentially enrich ^{6}Li, rendering Li isotopic (δ^{7}Li) a robust tracer of continental weathering intensity. In this study, we investigate late Quaternary continental silicate weathering processes in high-latitude Arctic regions and their responses to glacial-interglacial cycles by analyzing Li isotopic compositions of Arctic Ocean core sediments, combined with Sr-Nd isotopic data. Results reveal that core ARC5-ICE6 sediment maintained a stable provenance since 700 ka, mainly from East Siberian rivers and shelves input. The δ^{7}Li values of sediments range from -1.29‰ to +1.02‰, closely resembling the UCC (0±2‰). A gradual decline in δ^{7}Li values suggests enhanced continental weathering since 700 ka, potentially linked to progressive cooling in the Arctic following the Mid-Pleistocene Transition (MPT). Weathering processes of Arctic regions are dominated by glacial erosion-driven physical weathering. Glacial transport increases bedrock comminution, substantially amplifying mineral specific surface areas and facilitating chemical weathering. Therefore, intensified glacial grinding under colder temperatures may enhance chemical weathering intensity in polar sediments. During glacial-interglacial cycles, interglacial periods (e.g., MIS 9, MIS 11) exhibit more negative δ^{7}Li values compared to glacial periods (e.g., MIS 8, MIS 12), indicating stronger weathering intensity during warm intervals. This pattern highlights the dominance of climatic cycle in regulating chemical weathering evolution. Meanwhile, increased riverine input of secondary minerals during interglacials, coupled with glacier meltwater-enhanced mineral reactivity, may further drive the reduction of δ^{7}Li.

This study clarifies high-latitude continental weathering characteristics and their response to climatic factors, and expands the application of silicate Li isotopes in tracing weathering processes. It provides new geochemical constraints for understanding Arctic continental weathering mechanisms across glacial-interglacial cycles.