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An optimized protocol for Tl purification from natural samples for high-precision Tl isotopic measurements using MC-ICP-MS

ZHEN ZENG[1], HAOYE TANG[1], YUFANG SUN[1], YAN WANG[1], YI-BO LIN[2] AND FEI WU[3]

[1]Institute of Soil Science, Chinese Academy of Sciences
[2]Nanjing University
[3]China University of Geosciences

Thallium (Tl) isotopes have emerged as a powerful geochemical tracer for investigating geological and environmental processes. Conventional chemical purification methods predominantly employ anion exchange resins, where Tl is oxidized to its trivalent state (Tl^{3+}) using Br_2, forming anionic complexes that bind to the anion exchange resin. Subsequent elution of matrix elements is typically followed by Tl reduction and elution using SO_2 solution, thereby achieving efficient separation of Tl. However, this approach inevitably introduces sulfate, which causes significant matrix effects during instrumental measurement.

In this study, we present a novel reductive elution system specifically designed to eliminate matrix elements caused by reducing agents. The optimized protocol demonstrates exceptional separation efficiency, achieving Tl recovery rates exceeding 99% while avoiding Tl isotopic fractionation. High-precision Tl isotopic measurements were conducted using multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS), with instrumental mass bias corrected through W-doping methodology. Through systematic analysis of a series of reference materials from the United States Geological Survey (USGS) and the Institute of Geophysical and Geochemical Exploration (IGGE) of the Chinese Academy of Geological Sciences, the measured $\varepsilon^{205}Tl$ values are consistent with the published data within the uncertainty, confirming the reliability of this method for analysing natural samples with complex matrices. Based on the long-term analysis of in-house standard solutions and reference materials, the long-term precision of $\varepsilon^{205}Tl$ can be better than ±0.6 (2SD). This technological advancement provides strong analytical support for deciphering the Tl isotope geochemical cycle in various geological and environmental systems.