High-precision Ti isotopic analysis of igneous rocks using a double-spike method with MC–ICP–MS

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High-precision Ti isotopic analyses by MC–ICP–MS are described, with prior Ti separation being achieved by ion exchange chromatography using Bio-Rad AG® 1-X8 anion exchange and DGA resins. For igneous samples such as andesite, basalt, dolerite, and vanadium titanomagnetite, a two-column procedure was used, while for high-Fe/Ti and high-Mg/Ti samples a three-column procedure was required. Isotopic compositions were determined by MC–ICP–MS in medium-resolution mode ($M/\Delta M$ = 5000). Instrumental mass bias was corrected using a ^{47}Ti–^{49}Ti double-spike technique. The ^{47}Ti–^{49}Ti double-spike and SRM 3162a were calibrated using SRM 979-Cr by a two-step process assuming $^{53}Cr/^{52}Cr_{true}$ = 0.11339. Standard Alfa-Ti was analysed repeatedly over a ten-month period, indicating a reproducibility of ±0.08‰ for $\delta^{49/46}$Ti, comparable with precisions obtained for geochemical reference materials. Matrix effects were evaluated by analysing Alfa-Ti doped with Na, Mg, Cr, V, P, and Mo, with results indicating that high concentrations of Na, Mg, Cr, and V have no significant effect on Ti isotopic analyses. However, Mo and P interferences lead to erroneous $\delta^{49/46}$Ti values when Mo/Ti and P/Ti ratios exceed 0.5. Eleven reference materials (BCR-2, BHVO-2, GBW07105, AGV-1, AGV-2, W-2, GBW07126, GBW07127, GBW07101, JP-1, and DTS-2b) were analysed, yielding $\delta^{49/46}$Ti values of −1.64‰ ± 0.08‰, −1.65‰ ± 0.05‰, −1.56‰ ± 0.07‰, −1.50‰ ± 0.06‰, −1.54‰ ± 0.08‰, −1.57‰ ± 0.05‰, −1.67‰ ± 0.05‰, −1.56‰ ± 0.08‰, −1.50‰ ± 0.08‰, −1.34‰ ± 0.06‰, and −1.68‰ ± 0.03 (2 SD), respectively. Analysis of naturally occurring isotopic variations is a promising tool for investigating Ti transport and cycling in geological systems.