Use of 10^{13} ohm resistor amplifiers for double-spike barium isotope measurements by TIMS and MC-ICP-MS

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Ba (barium) isotope measurements have been applied to study the formation of the early solar system, the heterogeneity of mantle caused by crust recycling, ocean circulation, and paleo-ocean production reconstruction. Precise and accurate measurements of Ba isotope ratios could be achieved with the development of mass spectrometric techniques such as thermal ionization mass spectrometry (TIMS) or multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS). A recent advance for the mass spectrometer is the development of the amplifiers which are equipped with the state-of-the-art 10^{13} Ohm resistors in the feedback loop for the collection of the small ion beam. Compared to default 10^{11} ohm resistors, the use of a high-resistance 10^{13} ohm resistor results in tenfold improvement in the signal to Johnson noise ratio.

In this work, we establish a method for high precision stable Ba isotope analysis. Bio-Rad AG50W-X12 resin is used to separate Ba from matrix elements. ^{135}Ba-^{136}Ba double-spike is applied to calibrate instrumental mass bias. Ba isotope results are reported as $\delta^{138/134}$Ba values relative to standard reference material NIST 3104a ($\delta^{138/134}Ba=[(^{138}Ba/^{134}Ba)_{sample}/(^{138}Ba/^{134}Ba)_{NIST3104a}-1)]\times1000$). Isotope analyses are conducted on both TIMS and MC-ICP-MS (Triton Plus and Neptune Plus, Thermo Fisher). The measurements of two reference materials (ICPUS-Ba and USTC-Ba) with default 10^{11} ohm resistors with beam intensity of ~4.5pA for ^{134}Ba show consistent result between TIMS ($\delta^{138/134}Ba_{ICPUS-Ba}$=-0.03±0.02‰, 2σ and $\delta^{138/134}Ba_{USTC-Ba}$=0.11 ± 0.02‰, 2σ) and MC-ICP-MS ($\delta^{138/134}Ba_{ICPUS-Ba}$=-0.03 ± 0.04‰, 2σ and $\delta^{138/134}Ba_{USTC-Ba}$=0.09 ± 0.05‰, 2σ), consistent with the published value within analytical errors [1]. Sigmificantly, preliminary tests on TIMS show that comparable high quality data ($\delta^{138/134}Ba_{ICPUS-Ba}$=-0.02 ± 0.04‰, 2σ, and $\delta^{138/134}Ba_{USTC-Ba}$=0.13 ± 0.04‰, 2σ) is obtained for very low beam intensity (~0.1pA for ^{134}Ba) with the use of 10^{13} ohm resistors. More measurement are being conducted to further test the performance of 10^{13} ohm resistors on both instruments, which could improve our ability for Ba isotope analysis for small sample sizes.

[1] Nan et al. (2018) GCA, 233, 33-49.