Small-scale isotopic analysis of geological materials using the Laser Ablation with Filter (LAF) sampling method

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Micro-scale isotopic analysis of geologic materials is getting more important in recent geochemistry. Although in-situ isotopic measurements with LA-ICP-MS or SIMS have played a central role in geochemical applications, these techniques are not necessarily suitable for isotopic analysis that requires chemical separation prior to mass spectrometry. In such cases, sampling with micro milling [1] or Laser Ablation in Liquid (LAL) [2] has been applied. However, these sampling techniques could cause cross contamination from the micro-drill material, relatively low recovery yield, and longer sampling time.
To overcome these problems, we developed the Laser Ablation with Filter (LAF) method in which sample particles ablated by a fs-laser (IFRIT, Cyber Laser) are carried via the flow of He gas in a Teflon tube and then caught by a membrane filter (pore size: 0.1 μm). The performance of the LAF method was evaluated by using a glass standard (NIST SRM 610), which was ablated by a spiral analysis mode with a fluence of 28 J cm-2, repetition rate of 500 Hz, pulse lengths of 240 fs, wavelength of 260 nm, and raster speed of 100 μm/s. The typical pit size was 20 μm in width and 20 μm deep, which required 1.4 h for sampling an area of 1×1×0.1 mm3. The sample particles retrieved by the filter were dissolved by a mixture of HF and HNO3, then treated with HClO4 to decompose insoluble fluoride precipitates. The sample solution was split into two aliquots; one dedicated for the analysis of trace element abundances with ICP-MS (Xseries 2, Thermo) and the other for isotopic analysis with TIMS (TRITON plus, Thermo) after chemical separation. We found that the recovery yields of trace elements ranged from 80-90%, in which the effect of elemental fluctuation was suppressed owing to the use of the fs-laser [2, 3]. The 87Sr/86Sr of NIST 610 collected by the LAF method was 0.7096787 ±0.0000016 (2SE), which is consistent with that for NIST 610 (87Sr/86Sr = 0.7096779 ±0.0000028) separately measured by dissolving a piece of the glass standard. The procedural blank of the LAF method was negligible to perform the trace element and isotopic analyses. The new method can be applied to small minerals and inclusions in terrestrial rocks and meteorites for understanding the carrier phases that cause isotope heterogeneities in mantle rocks and refractory inclusions in carbonaceous chondrites. [1]Myojo, K. et al. (2018) Astrophys. J. 853, 48. [2]Okabayashi, S. et al. (2011) J. Anal. At. Spectrom, 26, 1393-1400. [3]Fernández B. et al. (2007) TrAC. 26, 951–966.

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