

## Synchrotron X-ray fluorescence microtomography in geo-, cosmo-, and bio-chemistry

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Synchrotron-based X-ray fluorescence computed microtomography is a unique method for imaging major and trace element distributions within natural materials non-destructively and with high spatial resolution. The technique is particularly useful in imaging and quantifying elemental abundance in small objects that may be too precious or too difficult to section, or in the analysis of materials in which sectioning may potentially alter elemental distributions. This presentation will highlight how this technique is being applied at beamlines X26A at the National Synchrotron Light Source (Brookhaven National Laboratory) and at 13-ID at the Advanced Photon Source (Argonne National Laboratory). Both instruments utilize 1-10  $\mu\text{m}$  diameter focused, monochromatic X-ray beams to non-destructively measure x-ray fluorescence from a sample as it is translated and rotated within the beam. The resultant fluorescence intensities are then reconstructed as either two-dimensional cross sectional or three-dimensional elemental distribution using a fast fourier transform based computational reconstruction algorithm. Reconstruction of multi-elemental distributions at concentrations down to approximately  $1 \mu\text{g g}^{-1}$  (element dependent) can be obtained. By collecting and storing full energy dispersive spectra from a multi-channel analyzer for every pixel (rather than regions of interest), it is possible to evaluate a reconstructed spectrum within the object for more robust elemental analysis. For high density matrices in particular, corrections are necessary to account for x-ray absorption by the object of both incoming X-rays and outgoing fluorescent X-rays. These effects limit the size of objects and elements that can be imaged; however reasonable corrections can be made if an estimate of linear absorption coefficient through the material is made. It is also possible to couple fluorescence tomography with microbeam x-ray absorption and diffraction analysis. Examples of materials analyzed by this technique at X26A and 13-ID include interplanetary dust particles, fluid inclusions, plant materials, and heavy metals sorbed to mineral grains.

## Age and Lu-Hf isotope systematics of RBT04262 and implications for the sources of enriched shergottites

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Enriched Shergottites are derived from sources that had sub-chondritic Lu/Hf and Sm/Nd ratios and are characterized by their relatively high incompatible trace element contents. New Lu-Hf age and isotope systematics of the recently discovered olivine-phyric shergottite RBT04262 (RBT) indicate that it is also an enriched Shergottite. These new data and existing Lu-Hf isotope data of enriched shergottites, place important constraints on the composition of this enriched martian reservoir and the timing of basaltic shergottite magmatic activity.

A 4-point Lu-Hf isochron defined by spinel, maskelynite, olivine, and clinopyroxene yields an age of  $225 \pm 21 \text{ Ma}$  ( $2\sigma$ ; MSWD = 0.71), which is interpreted as the time of magmatic crystallization. The initial  $^{176}\text{Hf}/^{177}\text{Hf}$  isotope ratio derived from the isochron is  $0.282135 \pm 0.000004$  ( $2\sigma$ ) and is similar to isochron-derived initial Hf isotope compositions of Shergotty and Zagami [1].

Based on the isochron initial  $^{176}\text{Hf}/^{177}\text{Hf}$  isotope ratio, the modeled source  $^{176}\text{Lu}/^{177}\text{Hf}$  isotope ratio for RBT is  $0.02735 \pm 0.00013$ ; the uncertainty in the source largely reflects the age error. Given the very poor reproducibility of  $^{176}\text{Lu}/^{177}\text{Hf}$  and  $^{176}\text{Hf}/^{177}\text{Hf}$  of whole rocks, an approach that estimates source Lu/Hf ratios derived from mineral isochron initial isotope compositions or a robust near-liquidus phase with a low Lu/Hf ratio such as chromite, yield better constraints on source compositions. Based on source Lu-Hf compositions derived from isochron initials, Shergotty, Zagami, and RBT04262 are derived from a source with the lowest Lu/Hf ratios whereas NWA856 and Los Angeles are derived from sources that had higher Lu/Hf ratios. Furthermore, RBT04262, Shergotty, and Zagami appear to be derived from sources with near identical  $^{176}\text{Lu}/^{177}\text{Hf}$  ratios. These new Lu-Hf data expand the duration of magmatism derived from the most enriched source recognized on Mars by  $\sim 30 \text{ m.y.}$

[1] Bouvier *et al.* (2005) *EPSL* **240**, 221-233.