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Utilizing dynamic SIMS for isotopic analysis of terrestrial and extraterrestrial materials

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Dynamic SIMS, including Nano-scale secondary ion mass spectrometry (NanoSIMS) and SHRIMP-RG (a large geometry, or LG-SIMS instrument), are unparalleled tools for providing high precision isotopic data sets in at relatively small spot sizes. Since these instruments can provide high mass resolution (M/ΔM) for most monatomic and some diatomic ions, dynamic SIMS is frequently utilized in the geosciences for both stable isotope ratio analyses and radiometric dating of minerals *in situ*.

We present recent work from the Stanford NanoSIMS that highlights high-precision stable isotope analyses for S^- and O^-. Historically, high-precision stable isotope analyses have instead utilized other methods such as large-geometry SIMS, MC-ICPMS, or TIMS. However, with further technique development researchers have now been pushing NanoSIMS stable isotope precision down to below ~5‰, into a range that is useful for understanding geologic and biologic processes that occur on earth and on other Solar System bodies (e.g., [1], [2]). We present NanoSIMS methods for spot analyses that bring $\delta^{34}S$ and $\delta^{18}O$ reproducibility on standards down to ~ 1‰ (1sd), providing sufficient resolution to observe isotopic fractionations in sulfides, carbonates, and oxides that can vary by up to ~tens of permil [3] in terrestrial and extra-terrestrial minerals.

In addition, we present methods for radiometric dating of terrestrial and extra-terrestrial materials using LG-SIMS. The SHRIMP-RG at Stanford is routinely used for U-series dating, particularly in zircon and apatite minerals from earth and beyond. We present methods and merits for using SIMS for geochronology, and also outline current work on developing better techniques for short-lived radiometric dating of extra-terrestrial materials using the ^{53}Mn-^{53}Cr decay system.

Lastly, this talk will also highlight the implementation of a custom glovebox, which makes the Stanford NanoSIMS the only instrument of its kind with the unique ability to perform air-free sample entry for the analysis of air-sensitive samples. The glovebox is equipped with a 3-way valve that allows for back-filling with either Ar or N_2 gas, suitable for a variety of different air-sensitive samples including Li-ion batteries or thin films, and sensitive space samples such as comet grains, meteorites, IDPs, or samples returned from missions (e.g., OSIRIS-REx).

References

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