

## **In situ stable isotope gas analysis enhanced four orders of magnitude**

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The geochemical cycles of the elements C, H, N, O, S and Cl involve biological processes which give different products from those predicted for an abiological system. This is because metabolic processes are major drivers of the geochemical cycles in a biotic system and impart significant isotopic changes. Thus, cataloging and balancing the isotopic compositions of different, often admixed, components within a system or microsystem can, when properly applied, define a biomarker. Geochemical investigations and the search for biosignatures require not only stable isotope analysis but also for it to be spatially resolved on various scales. This usually requires taking specimens back to the lab from the field and extraterrestrial material back to Earth, which is unlikely to happen until after Sample Return for most Martian samples.

We exploit a new analytical technology, *Capillary Absorption Spectrometry* (CAS), not used previously for any field or space flight instrument. It uses IR laser absorption spectrometry, similar in principle to that in TLS (part of SAM on MSL rover Curiosity) but instead of an analysis chamber, the sample is in a tapered, hollow optic fiber. This needs only a very small sample, while increasing gas interaction with laser light, reducing the amount needed by approximately four orders of magnitude and allowing isotopic analysis of 5 nanomole of CO<sub>2</sub> or H<sub>2</sub>O. We expect similar, extraordinary improvements in the analysis of other isotopic compounds.

Spatially resolved measurements utilize a second laser to produce a gas from the sample in a variety of ways: *Laser induced thermal decomposition* for C and O in carbonates and S in sulfates, *Laser volatilization* for H and O in hydrated minerals and ices, or *Laser induced reaction* with oxygen or hydrogen in a miniature reaction vessel allowing analysis of S in sulfide minerals, C and N in organic matter and Cl in chloride or perchlorate. Investigation of mass independent fractionation of O and S is also possible.

We will discuss how leveraging the reduced sample size and physical footprint of CAS greatly facilitates field and planetary science instrumentation while also adding fidelity to laboratory science investigations through improved spatial resolution and control of instrument analytical stability.