

Assessment of accuracy and precision for IRMS by standard material

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The setup of optimum condition for IRMS

As a result of this study, carbon isotope composition was very precise and accurate in a narrow range as well as a wide range of sample weight. The measured $\delta^{13}\text{C}$ value that was within the certified value $\pm 2\sigma$ had the minimum carbon contents in which EMA-P1 and EMA-P2 is 102.107 μg and 116.879 μg , respectively. Although nitrogen and sulfur isotope composition was less precise and accurate than carbon, the nitrogen content (18.650 μg) and sulfur content (27.839 μg) already had been within the certified value $\pm 2\sigma$. The variation of isotope composition was also investigated by the fractionation factor $\epsilon_{\text{applied}}$ that would explain the stability for $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ value. We suggest that carbon, nitrogen and sulfur isotope composition need to be determined by considering several factors; accuracy of $\delta^{13}\text{C}$ value and precision of $\delta^{13}\text{C}$ value, peak height ratio and fractionation factor $\epsilon_{\text{applied}}$.

Discussion of Results

Study on stable isotopes in contaminants is a relatively new concept with high potential of transforming a monitoring-based research paradigm into a more advanced one. In this study, a brand-new stable isotope analyzer was used and accuracy and precision were evaluated using carbon and nitrogen reference materials to establish the optimal analytical condition. And also, we can conclude that the analysis of stable isotopes in environment using a stable isotope analyzer is a promising new method for identifying the sources of contaminants.

[1] Jong-Yeon Hwang *et al* (2012) **NIER-RP2012-143**, pp.1-52. [2] Bo-Kyong Kim *et al* (2012) *J. of the Korean society for Environmental Analysis*, **15**(4), pp. 245-255. [3] Z. SHARP (2007) *Principles of Stable Isotope Geochemistry*.

Volcanic acid-sulfate analogs for early Mars

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Owing to Mars' prolonged history of volcanism, high heat flow, and copious surface water, we assume abundant hydrothermal systems persisted for significant time periods. Life on Earth may have originated in a similar setting and assessment of putative hydrothermal systems on Mars is paramount to assessing the planet's geochemical history and astrobiological potential. To this end, we have been assessing Earth and putative Mars hydrothermal systems through fieldwork, lab experiments, geochemical modeling, and remote sensing. Fieldwork at active basaltic volcanoes in Central America and Hawaii was used to document geochemical pathways of acid-sulfate alteration and resultant mineralogy. These results were correlated with environmental parameters (T, pH, fluid:rock ratio) to define the controls on alteration pathways. We find that extremely acidic pH and high temperature fumaroles rapidly alter the parent lithology into S, amorphous Si, with occasional crusts of gypsum. Moderately acidic (pH of about 4) fumaroles lead to abundant gypsum, natroalunite, Si, and Al-smectites. Mildly acidic and cooler fumaroles produce calcite and gypsum. Correlated laboratory experiments and geochemical modeling on whole basalts and individual mineral components have further defined the controls of acid sulfate alteration over a broad range of conditions and we found that high fluid:rock and temperatures lead to rapid dissolution of primary minerals and the liberated cations lead to a range of sulfates, amorphous Si, and hematite concretions. Remote sensing data from Mars reveals discrete locales of minerals indicative of acid-sulfate alteration and some were undoubtedly hydrothermal in origin. Our terrestrial studies provide a conceptual framework for interpreting the paleoconditions of ancient martian hydrothermal systems, where we are able to use the alteration mineralogy to infer the likely conditions of formation. Further, we have characterized the microbiology within active terrestrial volcanoes. While the hottest and lowest pH sites have minimal biomass, the moderately acidic and cooler fumaroles have diverse endolithic communities of photo- and heterotrophic aerobes and anaerobes.