

Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2024

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Category: ☒International Joint Research ☐General Joint Research ☐Joint Use of Facility
☐Workshop

Name of the research project:

Calibration of triple oxygen isotopic compositions of water reference materials

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Research report:

Purpose: The isotopic abundances of the three isotopes of oxygen (^{16}O , ^{17}O , and ^{18}O) are not well known as documented in the International Union of Pure and Applied Chemistry publication titled “Assessment of international reference materials for isotope-ratio analysis (IUPAC Technical Report)” by Brand et al. (<https://doi.org/10.1515/pac-2013-1023>). These isotopic abundances are important for calibrating isotope-ratio mass spectrometers and laser absorption spectrometers.

The aim of this project is to convert the most important oxygen-isotope water references to oxygen gas using the oxidizer bromine pentafluoride. The isotopic abundances of the three stable isotopes of oxygen will be determined by state-of-the-art dual-inlet isotope-ratio mass spectrometry at IPM and Georg-August-Universität Göttingen. It is anticipated that the results and their uncertainties will be published in a high visibility journal.

The oxygen isotopic abundances measured on water are particularly important because the two reference waters, VSMOW (Vienna Standard Mean Ocean Water) and SLAP (Standard Light Antarctic Precipitation), to be analyzed in this project are the anchors of the oxygen-isotope scale used in anthropology, atmospheric sciences, biology, chemistry, environmental sciences, food and drug authentication, forensic applications, geochemistry, geology, oceanography, and paleoclimatology.

There are only a limited number of laboratories in the world capable of performing high-precision triple oxygen isotope analysis of water samples by the fluoride method, and IPM is internationally known to have the technique to perform the most accurate analysis of such samples. So, in this project, triple oxygen isotopic ratio ($^{17}\text{O}/^{16}\text{O}$ and $^{18}\text{O}/^{16}\text{O}$) of 14 reference water materials issued by IAEA and USGS will be measured. TBC will send all the 14 reference water materials including VSMOW, VSMOW2, SLAP, SLAP2, GISP, and GRESP stored in the glass amples together with glass containers to IPM. RT will extract O_2 from each reference materials by fluorination method, then measure its isotopic ratios by isotope ratio mass spectrometer with dual inlet mode. All the data will be normalized to VSMOW-SLAP scale.

Results: Precise oxygen isotopic ratios of $^{17}\text{O}/^{16}\text{O}$ and $^{18}\text{O}/^{16}\text{O}$ of the 14 USGS reference waters were successfully measured at IPM, and all data were normalized using the VSMOW-SLAP scale. The $\delta^{18}\text{O}$, $\delta^{17}\text{O}$, and $\Delta^{17}\text{O}$ values of all the results ranged from -55.5 to +5.5 ‰, from -29.7 to +2.9 ‰, and from -33 to +50 ppm, respectively, with the standard error of the mean of each reference water being $\delta^{18}\text{O}$, $\delta^{17}\text{O}$, and $\Delta^{17}\text{O}$ as <0.071‰, <0.039‰, and $\Delta^{17}\text{O}$ <10 ppm, respectively.

Outcome: We are awaiting results from the Georg-August-Universität Göttingen. Once all data were measured, data comparison the result will be published in a high-impact international journal. Part of the data measured in IPM will be presented at the Goldschmidt 2025 meeting.