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高知コア研究所におけるSIMSを用いた高精度局所同位体比分析法開発の取り組みと、今後の研究の展望
A current status of high precision in situ isotopic analysis by SIMS in JAMSTEC and perspectives for future researches

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Secondary Ion Mass Spectrometry (SIMS) has a unique capability of isotopic and elemental measurements for micrometer-scale distributions in region-of-interests in variety of samples. With this unique capability, researches with SIMS brought out new evidence for understanding of processes occurred under extreme environment (e.g., Earth's earliest crust formation, reactions in Earth's deep interior, and high temperature processes in the solar nebula) and processes caused by biological/biochemical activities (e.g., biomineralization, metabolic functions of microorganisms).

While SIMS is a destructive technique, required amount of sample with SIMS analyses is very small (e.g., for oxygen two-isotope analysis, less than 1ng with a pit of ~10 micrometer in size and ~1 micrometer in depth) [e.g. 1,2]. SIMS analysis with a smaller beam and improvement of efficiency of analysis are highly required for multilateral analyses of the same sample.

A large geometry and ultra-high sensitivity magnetic sector SIMS with multiple detectors (CAMECA IMS 1280-HR) was installed in the Kochi Institute for Core Sample Research, JAMSTEC in early 2014. The Kochi's latest generation IMS 1280-HR has a capability to perform in-situ stable isotope analyses with sub-permil (down to +/-0.2 permil, 2SD) precision and accuracy for samples of a few to tens micrometer in size [1,3].

Here, we will present preliminary results of oxygen two-isotope ($^{18}O/^{16}O$) measurements in selected minerals using two Faraday cup detectors in multi-detection, and the Pb three-isotope ($^{206}Pb/^{207}Pb/^{208}Pb$) measurements in several standard materials using an axial electron multiplier detector with mono-collection. The achieved spot-to-spot reproducibility for $^{18}O/^{16}O$ is ~+/-0.3 permil (2 SD) with a ~10 micrometer spot for silicates and carbonates. The achieved precision and spatial resolution are promising to explore seasonal variations of precipitation recorded in speleothems [e.g., 4]. The spot-to-spot reproducibility for Pb three-isotopes is ~+/-7 permil with a ~20 micrometer spot for USGS BCR-2G standard glass ([Pb]=11ppm). Developed Pb isotopic measurements can be applied to researches for glass inclusions entrapped in minerals, which elucidate heterogeneity of the Earth's mantle [e.g., 5]. In the future work, we will use multiple electron multipliers to detect three Pb isotope signals simultaneously. This may provide better precision with a smaller spatial scale (~10 micrometer).

In addition to the development of high precision and high spatial resolution analysis with SIMS, we are planning to build a coordinated analytical system which provides information of microstructure and elemental/isotopic distributions for smaller-scale samples, such as a piece of asteroid which will be returned by the JAXA Hayabusa-2 mission in 2020 and samples of the ultra-deep drilling by Chikyu.

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