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Systematic analyses of volatile abundances, hydrogen and sulfur isotope ratios of melt inclusions

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Water and other volatile contents, hydrogen and sulfur isotopic signatures are useful to understand input of volatiles from subducted materials and evolution of magmas. Due to high mobility and reactivity of volatiles, measurements of fresh quenched glasses or glassy melt inclusions in robust minerals are required. Here, we report recent progress of combined in-situ analysis techniques of volatile (CO_2, H_2O, F, S, Cl) and P_2O_5, hydrogen and sulfur isotope ratios of silicate glass by SIMS, CAMECA IMS 1280-HR at Kochi Institute, JAMSTEC.

We established standard glasses (EPR-G3, IND-G1, IND-G2, FJ-G2, MRN-G1 for volatile abundances, EPR-G3 for $d^{34}S$, EPR-G3 and HW-G2 for dD) [1,2].

We firstly measure volatile abundances of samples using a ~10um in diameter Cs^+ beam. The secondary ions ($^{12}C^-$, $^{16}OH^-$, $^{19}F^-$, $^{30}Si^-$, $^{31}P^-$, $^{32}S^-$, $^{35}Cl^-$) are detected by an axial EM using a magnetic peak switching method. Volatile element signals are normalized to the Si signal for data reduction. Reproducibility of all volatile data of the running standard EPR-G3 in each session is ~2%, and the session-to-session variation of the slopes of calibration lines is within 10% for four years [1]. Since the $^{16}OH^-$ yield significantly and systematically changes with glass chemistry, we apply proper correction factor to calculate water content based on glass chemistry [3].

If samples contain [H_2O]>0.5wt% and [S]>500 ppm, we perform dD and $d^{34}S$ measurements. For dD measurements, a ~15um Cs^+ beam is used and the secondary ions ($^{16}OH^-$, $^{16}OD^-$) are detected by FC-EM detectors, simultaneously. Reproducibility of dD is ~±6‰ (2SD, [H_2O]>1wt%) [2]. For $d^{34}S$ measurements, a ~10um Cs^+ beam is used and secondary ions ($^{32}S^-$ and $^{34}S^-$) are detected by FC-EM detectors, simultaneously. Reproducibility of $d^{34}S$ is ~±0.7‰ (2SD, [S]>1000 ppm) [2]. We can perform volatiles, dD, $d^{34}S$ measurements for melt inclusions with ~40 um in diameter. If melt inclusions contain large pyrite grains, we can perform S 4-isotope measurements [4].

[1] Shimizu et al. (2017) Geochem. J., 51, 299. [2] Shimizu et al. (2019) Geochem. J., 53, 195. [3] Shimizu et al. (2022) Geochem. J., 56, 223. [4] Ushikubo et al. (2014) Chem. Geol., 383, 86.