FTIR spectroscopy and noble gas mass spectrometry for a single olivine grain

FTIR spectroscopy and noble gas mass spectrometry for a single olivine grain

*仁木 創太[1]、角野 浩史[2]、小林 真大[3]、鍵 裕之[1]、平田 岳史[1]、Ballentine Chris[4]
*Sota Niki[1], Hirochika Sumino[2], Masahiro Kobayashi[3], Hiroyuki Kagi[1], Takafumi Hirata[1], Chris J. Ballentine[4]

1. Geochemical Research Center, Grad. School of Science, Univ. of Tokyo、2. Dept. of Basic Science, Grad. School of Arts and Sciences, Univ. of Tokyo、3. Tokyo Metropolitan Industrial Technology Research Institute、4. Dept. of Earth Sciences, Univ. of Oxford
1. Geochemical Research Center, Grad. School of Science, Univ. of Tokyo, 2. Dept. of Basic Science, Grad. School of Arts and Sciences, Univ. of Tokyo, 3. Tokyo Metropolitan Industrial Technology Research Institute, 4. Dept. of Earth Sciences, Univ. of Oxford

Volatiles have been degassed from the mantle and recycled back into the mantle at subduction zones. Water is the main component of volatiles and plays a key role in dynamics of the subduction zones because even a small water content in rocks has an influence on the physical and chemical properties of the rocks (e.g. friction coefficient, melting point, etc.) which are closely related to phenomena studied in earth sciences including volcanic or seismic activities. It is still unclear to what extent of water have been subducted into the mantle and released to the Earth’s surface. To elucidate the volatile recycling, noble gases are powerful tracers because they have unique compositions in geochemical reservoirs. Previous researches have mainly reported results of bulk analysis of mantle peridotites. On the contrary, in this study, FTIR measurements and noble gas analysis of a single olivine grain were conducted to determine the noble gas concentrations in fluid inclusions.

The olivine samples used for this study were separated from mantle xenoliths collected from an intraplate setting (Hualalai in Hawaii) and two subduction zones (the Avacha volcano in the Kamchatka arc and the Pinatubo volcano in the Luzon arc). The Hualalai olivine was expected to show mantle-derived noble gas compositions (Kobayashi et al., G-cubed 2019) and was used for checking the accuracy of noble gas analysis. The Avacha and Pinatubo olivines contained H_2O-rich fluid inclusions and the noble gas concentrations in the inclusions had been estimated from salinities, and halogen and noble gas compositions (Kobayashi et al., EPSL 2017). The Avacha and Pinatubo olivines were used to confirm the accuracy of the analytical method used in this study for determining the noble gas concentrations in the inclusions.

FTIR measurements were conducted to determine the H_2O concentration in the Avacha and Pinatubo olivines. The mantle xenoliths were crushed into 0.5 to 2 mm and olivine grains were separated. The olivine grains were embedded in resin (Ortho Bright) and polished to a thickness of several hundred micrometers. The weight of samples was 0.7 to 16 mg. The H_2O concentration was calculated from the absorbance at 3404 cm^{-1}. After the FTIR measurements, resin was removed from each grain by heating at 50ºC and dissolving in acetone.

Noble gas analysis was conducted using multicollector noble gas mass spectrometers (Helix SFT and Argus, Thermo Fisher Scientific). After the sample loading into a laser heating cell, the cell was baked out

with pumping to desorb atmospheric noble gases to achieve low blank levels required for single-grain analysis. Consequently, noble gases were extracted by laser heating (Fusion Diode Stepped Heating System, Teledyne CETAC) at about 1000 ºC for 5 minutes. The gases released from samples were purified by removing active gases using a getter, and then, absorbed on two cryo-traps (one was for helium and neon and the other was for argon, krypton, and xenon). Each noble gas was desorbed from the trap at a certain temperature and introduced into the mass spectrometers. Helium was measured with Helix SFT and other noble gases were measured with Argus. The abundances and isotopic ratios of noble gases in a single olivine grain were obtained. The accuracy of the isotopic ratios was checked by the Hualalai samples.

The noble gas concentrations in the inclusions obtained will be compared with the previous bulk analysis to discuss the accuracy of the method in this study. This method of determining the noble gas concentrations in fluid inclusions from single-grain analysis has a potential to clarify the heterogeneity of the mantle volatiles in terms of a single-grain mineral and the flux quantification during the volatile recycling.

キーワード：noble gas、FTIR spectroscopy、mantle
Keywords: noble gas, FTIR spectroscopy, mantle

