Water content in olivine at the paleo-crust/mantle boundary recovered by the ICDP Oman Drilling Project

*Tomoaki Morishita[1], Muhamad Asyraf Aminuddin[1], Takayuki Ushikubo[2], Kenji Shimizu[2], Ryoko Senda[3], Masako Yoshikawa[4], Keita Itano[5], Akihiro Tamura[1]

1. Kanazawa University, 2. Kochi Core Center, JAMSTEC, 3. Kyushu University, 4. Hiroshima University, 5. Akita University

Small amounts of water and/or hydroxyl (OH) are incorporated into the structure of nominally anhydrous minerals in the mantle, such as olivine, pyroxene, and garnet (Bell and Rossman, 1992 Science). The amount of water in the Earth's mantle and its changes over time reflect the history of the Earth. The water content of olivine/pyroxenes in abyssal peridotites is measured, and these values are higher than expected for minerals in residual peridotites (Warren & Hauri, 2014 JGR; Hesse et al., 2015 Lithos; Schmäicke et al., 2018 Geochem. Geophys. Geosys.; Li et al., 2020 Sci. Rep.). The reason for the high water content of olivine and pyroxene in abyssal peridotites is not yet understood.
Since it is not possible to sample directly from the crust-mantle sequence, we use samples obtained from ophiolites as oceanic plates exposed from the seafloor. Core samples were collected from the Oman Ophiolite by the ICDP (International Continental Scientific Drilling Program) Oman Drilling Project. A continuous core sample of about 400 m was recovered with 100% recovery rate. Based on the core description conducted using the drilling vessel Chikyu in 2018, the recovered core samples are classified into four sequences. (1) Layered Gabbro Sequence, (2) Dunite I Sequence, (3) Dunite II Sequence, and (4) Mantle Sequence.
The serpentine around the olivine was removed as much as possible when removing the olivine grains from the polished core sample. Olivine grains were embedded in an Al disk sample holder of 2.5 cm diameter using indium metal. These procedures are essential to maintain good conditions for reducing the hydrogen background during analysis. The cleaned indium discs with olivine grains were placed in a high vacuum oven for a week to completely dry out the water contained in the samples. The indium discs were coated with Au and stored in a SIMS airlock chamber for at least 48 hours prior to analysis. Samples were analyzed using an IMS-1280 HR (AMETEK CAMECA PARIS, FRANCE) at JAMSTEC Kochi Institute for Core Sample Research (Shimizu et al, 2017). A 20 keV Cs+ ion beam was irradiated on the sample surface with a diameter of 15 μm at a current of about 4.5 nA. The secondary ion signals of 12C, 16OH, 19F, 30Si, 31P, 32S, and 35Cl were collected. First, we tested the effect of serpentine nearby the water content analysis spot of olivine grains. We compared data from areas along and away from the serpentine in the same olivine grain, and confirmed that, unless the Cs+ beam directly hit serpentine, the neighboring serpentine had no effect in the water content analysis of olivine grains in the studied samples. The water content of olivine in gabbros are 34 ppm on average and 20-50 ppm in dunite and harzburgite. Note that these water contents are still tentative.
The water content of the minerals in the residual peridotite is nearly zero after more than 10% melting and melt extraction from the depleted MORB mantle source. One possible reason for the high water content of olivine in residual peridotite is hydrous melting, in which melting occurs due to the influx of water components. The presence of magnesiohornblende in harzburgite may support a hydrous melting origin of the Mantle Sequence. Another interesting observation is that olivine grains with high water content in dunite samples tend to have larger deviations of the OH- signal during analysis. These grains with high water content are also characterized by submicron-scale exsolution of magnetite and clinopyroxene. The occurrence of exsolution of magnetite and clinopyroxene in olivine grain could affected the water content in samples. The origin of the submicron-scale exsolution of olivine grains may

be the key to the high water content olivine in dunite samples.

Keywords: Oman ophiolite, ICDP, mantle, water content, olivine, SIMS

