Imaging Analysis of trace elements for high pressure minerals using LA-ICP-MS

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In order to investigate details of the Earth's deep interior, it is required to analyze the run product of high pressure experiments with highly sophisticated technique. Major and minor element concentrations of the sample are analyzed by EPMA, while trace elements are generally analyzed by using Laser Abration-Induction Coupled Plasma-Mass Spectroscopy (LA-ICP-MS), and Secondary Ion Mass Spectroscopy (SIMS). In these trace element measurements, an area with a few tens of microns in diameter is abrated by laser beam or ion beam, and quantitative analysis is performed. In recent years, two-dimensional imaging analysis has been made by LA-ICP-MS, and this technique has been used for qualitative analysis of trace element distributions in the sample. However, such data also can be used for quantitative analysis by adopting new data processing technique. In this study, the run products of high pressure melting experiments were analyzed by LA-ICP-MS imaging technique. The results are not only used for the qualitative two-dimensional distribution analysis of trace elements, but also used for estimation of the quantitative trace element concentration in high pressure minerals and silicate melts.
In this study, a peridotitic composition powder, which is doped with trace elements in approximately 200 ppm, was used for the starting material. High pressure melting experiments were performed by a Kawai-type multi anvil press installed at Tokyo Institute of Technology. In order to obtain large sized crystals of high pressure minerals, the temperature of the sample was raised above the liquidus, and then slowly cooled down to the desired temperature. Once the temperature reached the final target temperature, the sample was held for 30 to 60 minutes, and quenched isobarically. The recovered specimen was polished and their major and minor element compositions were determined by EPMA. Two-dimensional trace element analysis was performed by LA-ICP-MS at Kyoto University. This system is consisted of ArF Excimer laser and quadrupole-type ICP-mass spectrometer. The sizes of laser beam used in the present imaging analysis were 10 to 20 microns. In the run products, garnet and wadsleyite were found as liquidus phases at 17 GPa. Under higher pressure conditions, liquidus phase changed to garnet + ferropericlase, and at above 23 GPa, they were bridgmanite + ferropericlase. The crystal sizes of these liquidus phases were larger than 50 microns except in ferropericlase. Compositional gradients of trace elements were found in large sized high pressure minerals by LA-ICP-MS imaging analysis. These compositional gradients must be originated from the slow cooling step in the present high pressure experiments. Compositionally homogeneous regions in high pressure minerals were selected from imaging analysis, and trace element concentrations were calculated. Partition coefficients between minerals and silicate melt were estimated from these quantitative results. The acquired partition coefficient values are consistent with the results which were obtained by the “normal” LA-ICP-MS analysis.

Keywords: high pressure minerals, trace elements, imaging

