Unraveling the generation process of granitoid magmas in the Hidaka Metamorphic Belt by in situ geochemical and Sr isotopic analyses of plagioclase

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In order to understand the growth history of continental crust, it is essential to reveal the importance and mechanism of crustal reworking processes. The contribution of pre-existing crustal rocks to granite genesis has been investigated using Sr isotopes because old crustal rocks have higher $^{87}Sr/^{86}Sr$ as compared to juvenile magma. However, since granites often involve multiple magmatic sources, it is difficult to unravel the nature of the sources from whole rock Sr isotope analysis. Nowadays, in situ analysis of minerals for trace elements and isotope ratios becomes popular to overcome these difficulties.

To better understand granitoid genesis and crustal reworking process, we present a combined Sr isotopic and major and trace element geochemistry by in situ analysis of plagioclase in granitoids from the Hidaka Metamorphic Belt (HMB) in Hokkaido. The HMB exposes a cross section of arc crust is exposed and, therefore, lower crustal rocks are available for direct analysis. The HMB is mainly composed of metamorphic rocks reaching to granulite facies and igneous rocks intruding into them. This study focused on the northern part of the HMB where various igneous rocks are exposed. All samples used in this study were collected in the field trip at the northern HMB. Eight samples which represent the typical geological setting of this part are chosen for the analyses.

We performed in situ analyses of plagioclase as well as other minerals for major elements by an electron microprobe micro analyzer (EPMA), for trace elements by a laser ablation inductively coupled plasma quadrupole mass spectrometer (LA-ICP-QMS), and for Sr isotope ratio by a laser ablation multiple collector inductively coupled plasma mass spectrometer (LA-MC-ICP-MS). We analyzed multiple spots in single crystals to evaluate geochemical and isotopic heterogeneities. All Samples were analyzed in solid state as thin section.

The EPMA and LA-ICP-MS data revealed chemical and isotopic zoning in plagioclase crystals. In addition, different grains have different isotope signatures especially in the cores. In a tonalite sample, Sr isotope ratios in the cores split into two parts. By contrast, their rims have similar Sr isotope ratios. Given that the Sr isotopic ratios in the cores represent their source magma compositions, these observations can be interpreted as mixing and homogenization processes in the source magmas having different origins. The higher isotope ratio overlaps those of sedimentary and metamorphic rocks in the HMB (Kojima et al., 2014), whereas the lower ratio overlaps those of mafic igneous rocks (Maeda et al., 2011). These results indicate that the tonalite source magma involves both juvenile and reworked crustal components. Assuming that the distinct core compositions respectively reflect the juvenile and reworked crustal components, we estimated the contribution of the crustal component to be 25% at most. On the other hand, two granite samples show less clear convergence or unified change in plagioclase composition compared to the tonalite sample. Strontium isotope ratios in all plagioclase crystals overlap the compositions of the sedimentary and metamorphic rocks or higher than them. It can be interpreted that these granites were generated dominantly by partial melting of sedimentary and metamorphic rocks.