Zircon geochemistry of felsic gneisses from Harvey Nunatak, Napier Complex in East Antarctica

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Zircon ($ZrSiO_4$) is the most widely used mineral for geochronological and geochemical investigations owing to its favorable properties, such as high physicochemical stability, adequate content of trace elements such as U, rare-earth elements (REE) (e.g., Armstrong-Altrin et al., 2018 and references therein), Li (e.g., Ushikubo et al., 2008) and exhibits good retention of radiogenic Pb (>900 °C; e.g., Cherniak, 2010 and references therein). Trace elements in zircon serve as indicators for estimating the source melt and the environment where it crystallized. Zircon U-Pb geochronology combined with trace-element geochemistry is a powerful tool for investigating the geochemistry of rocks that have experienced high-temperature environments. Zircon has become a powerful geochemical tool for Antarctic geological and petrological research. We found extremely lithium (Li)-enriched zircons ([Li]: ~300-600 ppm) in an orthopyroxene-felsic-gneiss collected from Harvey Nunatak in the Napier Complex, East Antarctica by JARE-58 Geological Field Survey Team (Figure 1; Takehara et al., 2023). The Napier Complex, including Harvey Nunatak, experienced extremely high temperatures (>1100 °C) based on the mineral assemblage of sapphirine + quartz (Harley, 2016 and reference therein). The thermal history is essential for unraveling the earth's crustal evolution, including deep crust; however, geochronological constraints, such as the timing and duration of the metamorphic events, are still debated. We characterized the zircons of Harvey Nunatak based on the concentration of trace elements analyzed by a sensitive high-resolution ion microprobe (SHRIMP-IIe) in the National Institute of Polar Research (NIPR). The Li and oxygen isotope ratios in zircons are also analyzed by SHRIMP-IIe/AMC in NIPR.

The zircon grains in the Grt-bg. Opx-Qtz-Pl gneiss (sample No. 170223-2A-09) had no core-rim structure and were characterized by sector zoning and nebulous to fir-tree zoning, which is a common feature of zircon in granulite facies rocks. The U-Pb data of the unaltered domains of the zircons are scattered from 2524 to 2342 Ma, and the weighted average is 2493.1±9.7 Ma (MSWD =15). This weighted average age is statistically meaningless owing to the large MSWD, which indicates a mixture of multiple elements. The largest peak was centered at ca. 2470 Ma and was consistent with the weighted average ages of the zircon rims of the Opx-Pl gneisses (Sample Nos. 170223-2A-08 and 170223-2A-10). Therefore, it is considered that the zircons crystallized by regional metamorphism continued from 2524 to 2342 Ma, similar to the 170223-2A-08 and 170223-2A-10 samples.

The REE patterns of the 170223-2A-09 zircons were similar to those of the 170223-2A-08 and 170223-2A-10 zircons. The LREE-enriched patterns are probably affected by the altered domains and are probably derived from the altered domains surrounding the fractures (Takehara et al., 2018). The HREE-depleted patterns are similar to the REE patterns of zircon co-existing with garnet, shown in the sample of Mt. Riiser-Larsen reported by Hokada and Harley (2004). Lower Ti-in-zircon temperature (about 865 °C) is obtained from HVN 09 zircons, which show the average Ti-in-zircon temperature of 934 °C. The garnets localized in the 170223-2A-09 sample indicate that zircon grains were not entirely related to the garnets during regional metamorphism. The REE pattern of a spot, which indicates the U-Pb age of 2520 Ma, is similar to the lower middle-REE pattern in the 170223-2A-10 sample. There is a possibility that the REE pattern is derived from different crystallization conditions or inheritance affected by the U-Pb system disturbance; however, further studies are necessary.

The oxygen isotope ratios were consistent regardless of age, suggesting that the oxygen atoms were taken up into the zircons from the environment that was buffered from the minerals or melts, except for the zircon domains in the altered grains. The average $\delta^{18}O$ value is 4.93±0.12 ‰ and slightly lower than that of zircon in equilibrium with the mantle materials (5.3 ± 0.3 %; Valley, 2003), but it does not indicate that the protoliths of the sample rocks are of the mantle derivation because these zircons crystallized during UHT metamorphism. The $\delta^{18}O$ values in the unaltered domains of the altered grains are widely scattered compared to those of the unaltered grains. Some of them are probably attributed to the altered domains surrounding the fractures.

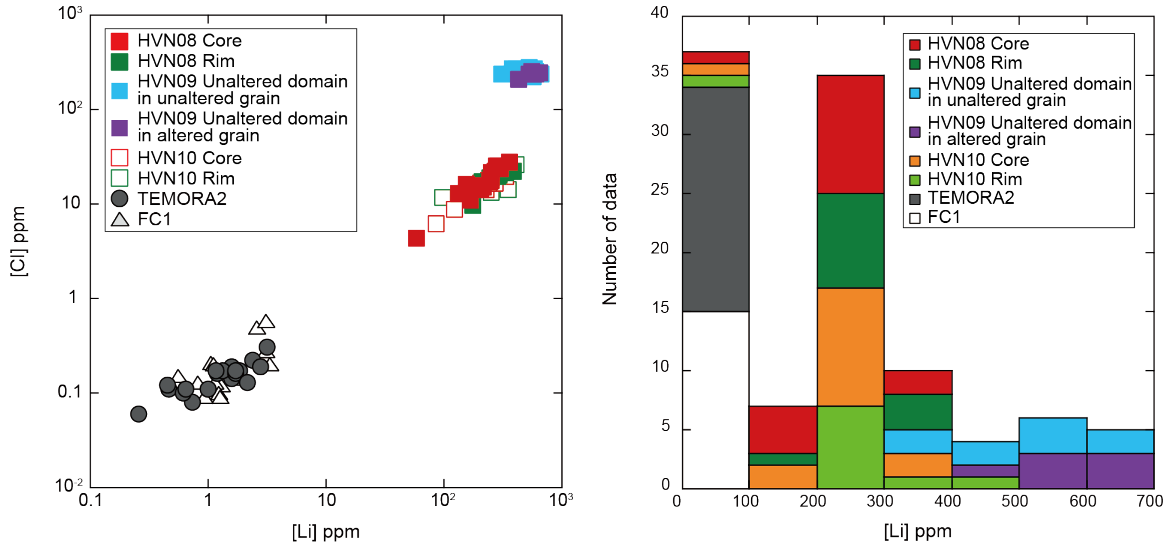

Figure 1. The characteristics of the Li and Cl in zircons. (a) Li content versus Cl content. (b) Histogram of Li contents. The data are obtained from 170223-2A-08 (HVN08), 170223-2A-09 (HVN09), and 170223-2A-10 (HVN10) zircons collected from felsic gneisses of Harvey Nunatak, and TEMORA2 zircon (Black et al., 2004), and FC1 zircon (Paces & Miller, 1993).

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