Thermal evolution of the Lanzo orogenic peridotite massif in western Alps: implications on thermal structure near subcontinental lithosphere-asthenosphere boundary

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Lithosphere-asthenosphere boundary (LAB) is a zone where heat, momentum, and materials are exchanged between conductive mantle and underlying convective mantle, and plays an important role in plate tectonics (McKenzie & Priestley, 2005; Fischer et al., 2010; Kawakatsu & Utada, 2017). Its internal structure and dynamic behavior are, however, far from understood. This study addresses this issue on the basis of petrological study of an orogenic peridotite complex. Lanzo massif in the western Alps, Northern Italy. We attempt to clarify temporal change of internal thermal structure of the complex during exhumation, from which the original thermal structures before exhumation may be estimated.
Lanzo massif is one of the largest mantle exposure thought to be a subcontinental lithospheric mantle exhumed related to the opening of the Jurassic Piedmont Sea between European continent and Adriatic continent, following slow spreading of the Atlantic mid ocean ridge (Müntener & Piccardo, 2003). The massif consists dominantly of plagioclase-bearing lherzolite, stable at the pressure lower than 1GPa, with subordinate amount of mafic rocks occurring as layers or dikes (Bodinier, 1988; Bodinier et al., 1991). The Lanzo massif divided into three bodies on the basis of petrographic characteristics: north, central and south. Previous studies argued that the northern part represents subcontinental lithospheric mantle and that the southern part may be of asthenospher origin (Bodinier, 1988; Bodinier et al. 1991). Therefore, the complex may represent a zone of lithosphere-asthenosphere boundary and can provide information on processes operated there (Bodinier, 1988; Bodinier et al., 1991; Kaczmarek & Müntener, 2008).
We examined plagioclase-bearing lherzolite collected from 16 localities covering the entire massif. Systematic variations of microstructures and mineral chemical compositions were confirmed, which is principally consistent with previous studies (Bodinier, 1988; Bodinier et al., 1991). All constituent minerals show chemical heterogeneity on grain scales, which is regarded as record of various processes the rocks underwent. Grain-scale zonings of Al and Ca in pyroxene, fluorescence-corrected Ca in olivine adjacent to pyroxenes, Cr and Al in spinel adjacent to plagioclase, and Ca and Na in plagioclase suggest that monotonous cooling and decompression accompanied by deformation occurred during decompression of the Lanzo massif. We quantified the space-dependent thermal history of Lanzo by using Ca-in-orthopyroxene geothermometer after Lindsley (1983) and Ca-in-olivine geothermometers calibrated on the basis of experimental results of Köhler & Brey (1990). All the estimated temperatures decrease from the southern body towards the northern body. The calculated temperatures were critically examined if they represent closure temperatures or a condition at which Lanzo resided for a certain period of time. The grain-scale zoning patterns indicate that the temperatures from core of orthopyroxene recorded a long residence, whereas those from rim of pyroxenes and both core and rim of olivine represent closure temperatures (Tc) at various timings during monotonous cooling. The decrease in temperatures of pyroxene cores from the south to the north by ~60K may represent a geotherm near LAB zone. All the Tc decrease from the north to the south and the difference of temperatures between the core and rim of orthopyroxene increases from the southern body to the northern body. This suggests that the cooler and probably shallower northern body cooled at slower rate at a wide temperature range

(Tc=700-1100˚C) than the hotter and probably deeper southern body. A thermal gradient recorded in the Lanzo massif is estimated to be ~6K/km, which is greater than those estimated for deep subcontinental lithosphere at steady thermal state (Mckenzie et al., 2005). We speculate that the high geotherm might have caused by thermal perturbation from asthenosphere.

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