一ノ目潟産スピネルカンラン岩捕獲岩から読み解くリソスフェア-アセノスフェア境界領域の構造と形成機構

Structure and formation mechanism of lithosphere-asthenosphere boundary decoded from Ichinomegata peridotite xenoliths

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Lithosphere-asthenosphere boundary (LAB) is one of the largest discontinuities in mantle where heat transfer mechanisms change from conduction to convection (Sleep, 2005, 2006). Various formation mechanisms of LAB have been proposed and still controversial (Green et al., 2010; Hirschmann, 2010; Hirth & Kohlstedt, 1996; Karato, 2010, 2012; O’Reilly & Griffin, 2006). Mantle xenoliths are fragments of mantle material (Nixon, 1987) and could have derived from the LAB zone and are useful to reconstruct its internal structure and to understand the ultimate cause of LAB zone and dynamic processes operated there. We have examined spinel peridotite xenoliths from Ichinomegata maar located in the back-arc side of NE Japan to address this issue (Sato & Ozawa, submitting to Ame. Min.; Sato & Ozawa, 2017, 2018, JpGU meeting; Sato & Ozawa, 2016, 2017, AGU fall meeting). We succeeded in reconstructing the structures and clarifying the formation mechanism of the LAB zone beneath Ichinomegata.

Ichinomegata maar is a latest Pleistocene andesitic-dacitic volcano yielding spinel peridotite xenoliths (Katsui et al., 1979). Diversities of thermal, chemical, rheological, and petrological features of the xenoliths have been documented by previous studies (e.g., Kuno, 1967; Kuno & Aoki, 1970; Takahashi 1980, 1986; Koyaguchi, 1986; Tanaka & Aoki, 1981; Abe et al., 1992, 1998; Abe & Yamamoto, 1999; Satsukawa & Michibayashi, 2014; Satsukawa et al., 2017). Despite the numerous data, the derivation depths of the xenoliths have never been seriously examined. We devoted our effort to geothermobarometry of spinel peridotite xenoliths, and successfully estimated derivation pressures and temperatures ranging 0.7-1.6 GPa and 828-1081 ˚C for 8 of the 9 examined xenoliths by examining the time scale of development of every chemical zoning to identify minerals, mineral portions, and chemical species attaining equilibrium as close as possible just before the xenolith extraction.

Various depth variations were clarified. The shallow mantle, ranging from 28 to 32 km, is characterized by low temperature, granular, and plagioclase- and amphibole-bearing mantle, and the deep mantle, from 41 to 55 km, by high temperature, porphyroclastic, and plagioclase- and amphibole-free and melt-bearing mantle. It is notable that the sample-derived solidus condition coincides with the depth of change of deformation microstructures. This indicates that the wet solidus controls rheological LAB zone beneath Ichinomegata. We infer that the shallow zone corresponds to lithospheric mantle and the deep zone to LAB zone.

Intimate correlations between the depth variations of absence or presence of plagioclase and amphibole and geochemical data obtained by previous studies (e.g., Tanaka & Aoki, 1981; Abe et al., 1998) enable us to reconstruct geochemical depth variation; clinopyroxene and whole-rock of plagioclase- and amphibole-bearing shallower peridotites are characterized by light rare earth element (LREE) depleted patterns, low $^{87}Sr/^{86}Sr$ ratios (~0.7027-0.7030), and high $^{143}Nd/^{144}Nd$ ratios (~0.5133-0.5134); in

contrast, those of plagioclase- and amphibole-free and melt-bearing deeper peridotites by LREE enriched patterns, high $^{87}Sr/^{86}Sr$ ratios (~0.7033-0.7047), and low $^{143}Nd/^{144}Nd$ ratios (~0.5125-0.5130).

Previous studies attributed geochemical diversity to local magma-related processes beneath MOHO (e.g., Takahashi, 1980; Abe et al., 1992). However, the systematic depth variations of geochemistry indicate a larger-scale stratification of the upper mantle beneath Ichinomegata. We infer that the shallower geochemically depleted mantle represents oceanic lithosphere formed during Japan Sea opening and that the deeper enriched mantle represents LAB zone which formed recently through lithosphere thinning by asthenospheric upwelling. A similar scenario was proposed by Ohki et al. (1994) on the basis of temporal variations of Nd-Sr isotopes from Middle Miocene.

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