A thermal structure of oceanic lithosphere constrained from mantle xenoliths from the petit-spot volcano

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The relative motion of the plates that covers the Earth’s surface controls various landform and plays an essential role in causing geological phenomena such as volcano and earthquake. The Earth’s plates are basically classified into continental plate or oceanic plate, based on the internal structure and thickness. However, the mechanisms by which both continental and oceanic plates formed, and their evolution remain putative. The petrological, chemical and thermal structures of Archean craton have been reconstructed extensively using mantle xenoliths. However, for the reason that insufficient mantle xenoliths have been recovered from the oceanic plate, the petrological, chemical and thermal structures of the oceanic plate are not well constrained yet. In 2000s, a new suboceanic volcano has been discovered on the ~140 Ma Pacific plate in the outer trench swell of the Japan Trench. This volcano, called petit-spot volcano, is known to contain mantle xenoliths derived from the old oceanic lithosphere in their basaltic host. Yamamoto et al. (2014) estimated the depth that the mantle xenoliths were originated using residual pressure of fluid inclusion for four mantle peridotites and indicated that the geothermal gradient beneath the petit-spot volcano may be much higher than that predicted for a 140 Ma oceanic plate. The purpose of this study is to re-examine the geothermal gradient beneath petit-spot volcano by examining the equilibrium temperature and pressure conditions recorded in five peridotite xenoliths collected during the Shinkai 6500 submersible diving at Site B petit-spot volcanic field during YK21-07S cruise.

The studied xenoliths are lherzolites containing fresh olivine, orthopyroxene, and clinopyroxene. The lherzolites can be subdivided into three groups based on the mineral assemblage: a lherzolite contains fresh garnet, two lherzolites are spinel-bearing, and the other two lherzolites do not contain aluminous mineral phases. Based on the quantitative chemical analysis of minerals conducted by a FE-EPMA, we applied a two-pyroxene thermometer formulated by Brey and Kohler (1990). The results show that the equilibrium temperatures reflect the mineral assemblages of the three types: spinel lherzolites were equilibrated at low temperatures (low-*T*: <600 ˚C), garnet lherzolite was in medium temperature (mid-*T*: ~900 ˚C), and other two lherzolites without aluminous mineral phases record very high temperatures (high-*T*: >1200 ˚C). An equilibrium pressure of the garnet lherzolite was determined to be 1.9 ±1 GPa by Al partitioning of garnet-orthopyroxene (Brey and Kohler, 1990), and those of the high-*T* group was determined to be 2.3-2.8 GPa by Ca partitioning of olivine-clinopyroxene (Kohler and Brey, 1990). Neither the high-T/P gradient estimated by Yamamoto et al. (2014) nor the low-T/P gradient predicted by the half-space cooling model, the geotherm gradient obtained in this study is in good agreement with the geothermal gradient predicted by the plate model (GDH1). Judging from the chemical zoning of the constituent minerals, the high-*T* group might have been influenced by thermal perturbation related to the petit-spot magmatism. However, the structural inconsistency of P-T with the half-space cooling model is obvious for the garnet lherzolite which retain homogeneous mineral compositions. The pyroxenes in the low-*T* spinel lherzolites exhibit a pronounced exsolution texture, indicating a steady cooling history. These results and observations led us to make two important implications: (1) thermal perturbation of the oceanic lithosphere by petit-spot magmatism is restricted to the deep section, and (2) the geotherm of the old oceanic lithosphere is consistent with the plate model (GDH1) rather than the half-space cooling model.

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[1] Yamamoto et al. (2014) *Chem. Geol.* **268**, 313-323 [2] Köhler and Brey (1990) *GCA* **54**, 2375–2388
[3] Brey and Köhler (1990) *J. Petrol.* **31**, 1353–1378.

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