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Observational and numerical studies of melt generation beneath petit-spot

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In 1997, anomalously young alkali-basalt lava (5.95±0.31Ma Ar-Ar age) was discovered at 39°23. 2'N, 145°15.5'E, on the oceanward slope of Japan Trench during ROV KAIKO dive (10K#56) (Hirano et al., 2001). To better understand the causes for the volcanisms, R/V KAIREI and YOKOSUKA cruises (KR03-07, KR04-08, YK05-06, KR05-10, KR07-06) were operated, during which we obtained geophysical data, and rock samples.
Bathymetry and backscatter image show presence of the layered lava fields over the oceanward slope of Japan Trench, as well as monogenetic volcanoes (Kaiko Knolls). Based on their ages (4-8 Ma) with the present absolute motion of the Pacific Plate (NNR-NUVEL1A), predicted original eruption sites distribute over a broad region (about 400 km in length) on the eastward slope of the outer rise (Hokkaido Rise).
Hokkaido Rise is an upward convex swell, resulting from lithospheric flexure associated with subduction of Early Cretaceous Pacific Plate into the Japan and Kuril Trenches. According to the plate subsidence models by Parsons and Sclater (1977), the 130 to 133 Ma part of the Pacific Plate, currently subducting beneath northern Japan, should be at a depth of approximately 6000 mbsl. Nevertheless, the shallowest part of the Hokkaido Rise is only 5200 mbsl. This lithospheric flexure may cause decompression and changes in flow patterns of uppermost mantle. If the melting condition is satisfied, decompression melting along flow lines could occur in an extensive area. To better understand a possible mechanism of magma generation, we construct numerical models of mantle flow and temperature structure, and compared with peridotite solidus with different water content (Iwamori, 2004). Under the dry condition, no melting occurs, while 0.06% water causes incipient melting at about 100km depth. As the water content increases, the region of which temperature is above solidus extends to about a depth of 270 km, while the melting region is limited at shallower than a depth of 120 km.
These results are consistent with probable origins, melting of garnet peridotite, estimated from geochemical analyses (Hirano et al., 2006). The trace element patterns produced by melting of A-DMM do not completely fit to those of sampled rocks. To explain the concentration of some elements such as La and Pb, aqueous fluid which contains those elements could have been added to the mantle beneath the region. Although the origin of the fluid is unknown, speculating from the relatively high abundance of Pb, it could have been leaked out from the neighboring subduction zones. Still, there is a conflict between observation and calculation: the melting degree estimated from the trace element pattern is 0.01%, while the melt fraction estimated in our numerical model is 5-10 % at the same water content. Further investigation concerning source composition, variable water content over space and time, melting degree affected by water content, and the type of melting (e.g., batch or fractional, non-modal or modal melting) is needed to find a solution quantitatively.

Keywords: petit-spot, melt, asthenosphere