PETROLOGICAL STUDIES ON THE QUATERNARY MAGMATISM IN THE NORTHERN SREDINNY RANGE

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Marginal parts of a plate and subducting slab play important role in geodynamics. This is because in areas where a plate interacts with other plates or with the mantle thermal, geochemical, and mechanical interactions are expected. How to propagate the force between plates is an important factor in determining the origin and intensity of the plate movement, in particular, the toroidal motion characterizing the Earth.

The northwestern edge of Pacific Plate is subducting beneath the northern Kamchatka (Fig. 1), which formed three volcanic lines consisting the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD) and the Sredinny Range (SR). In the west part of the boundary between the Pacific Plate and the North American Plate (or Bering Plate), three transform faults consisting of Aleutian Transform Zone (T.Z.), Bering T.Z. and Alpha T.Z. are formed along the northern edge of the Pacific Plate, which constitutes the forearc slivers (e.g., Komandorsky Sliver, Lay et al., 2017). The Emperor Seamount Chain is subducting with the edge of Pacific slab, which is thought to be related to the formation of the East Cone volcanic group (EC) in the fore-arc area and a massive active volcanic group, Klyuchevskoy Volcanic Group (KVG), in CKD (Dorendorf et al., 2000; Nishizawa et al., 2017).

In the Pacific slab edge, the mantle wedge is open to the north. However, the mantle thermal structure near the slab edge is still being debated as to whether the edge of the plate is hot or cold (e.g., Yogodzinski et al., 2001; Portnyagin and Manea, 2010). The along-arc direction of the mantle flow is also debated; if there is an asthenospheric flow around the plate edges and through the slab window, the hot asthenospheric mantle would flow southward in the wedge (Yogodzinski et al., 2001). On the other hand, if the wedge temperature decreases toward the slab edges, the mantle would flow northward in the wedge (Portnyagin and Manea, 2010).

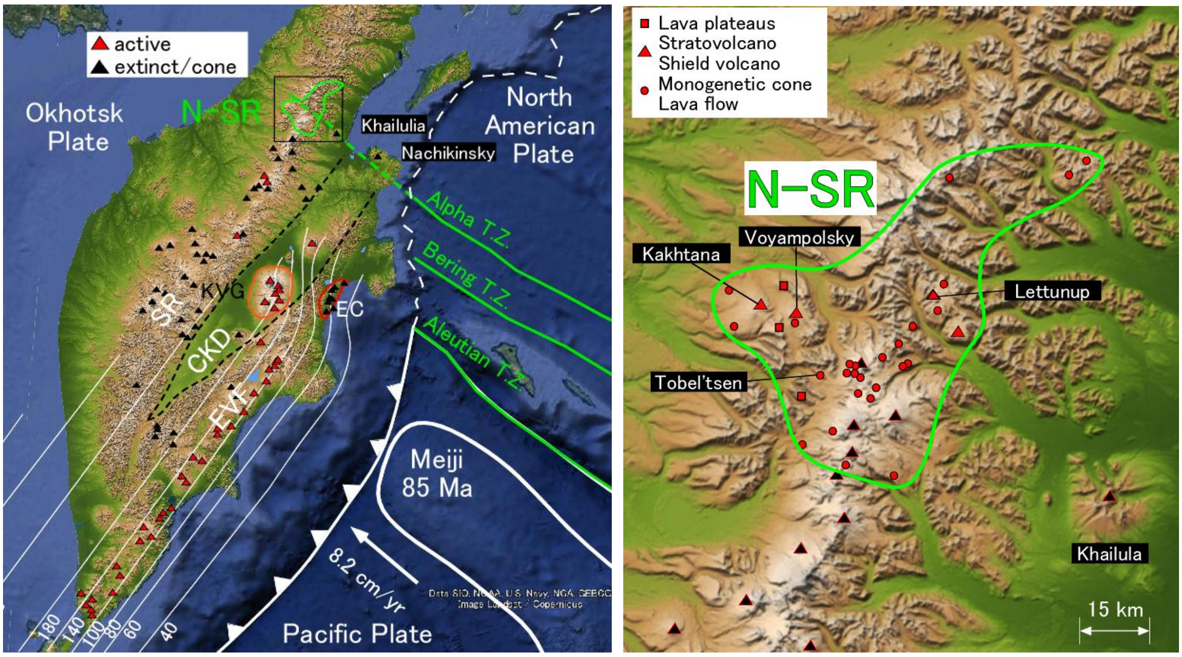

Fig. 1 *(left) Major geological structures of the Kamchatka and (right) detailed map of northern-Sredinny Range (N-SR).*

We found monogenetic cones and stratovolcanoes formed by Quaternary magmatism in the northern Sredinny Range (N-SR) from N58° 05' and up to N58° 38', more than 150 km northwest away from the point of intersection of the Kamchatka trench and the Aleutian trench (Fig. 1). In this study, we tried to constrain the slab-wedge dynamics in the northwestern edge of the Pacific Plate based on the petrological and geochemical characteristics of N-SR lavas and its geological settings.

The K-Ar and $^{40}Ar/^{39}Ar$ age data of the N-SR lavas represent that the magmatism started from the Lower Pleistocene (1.6~ Ma). The youngest active age is ~3.5 Ka reported from Tobel'tsen cone (Pevzner, 2006), which indicates that the magmatism in N-SR continues through the Quaternary. Most N-SR lavas contain olivine, clinopyroxene and plagioclase as a mineral assemblage, have a range in the SiO_2 content from 51 to 61 wt.% and are classified as medium-K series. In the trace elements spider diagram, the Quaternary N-SR lavas show relatively shallow Nb and Ta depletion compared to the lavas from the EVF and the EC, which is similar to the lavas from Hailulia and Nachikinsky volcanoes and the south-SR (Portnyagin et al., 2005; Volynets et al., 2010), but show a typical arc signature with relative LILE enrichment and HFSE depletion. It indicates that slab-derived fluid is distributed in the source mantle even in the north beyond the slab edge where the subducting slab is not recognized.

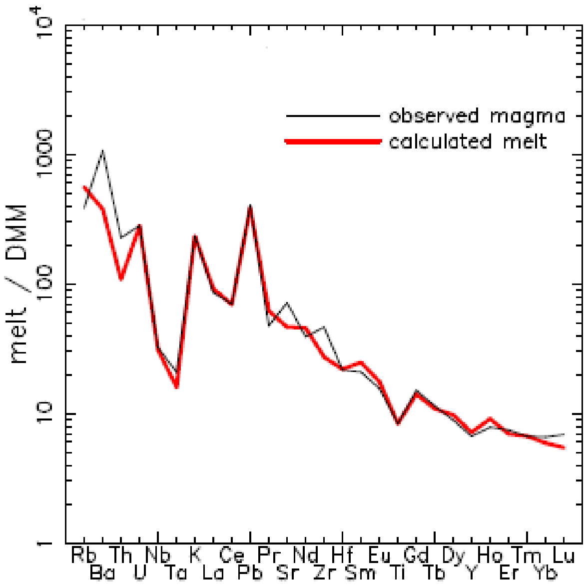

Fig. 2 An example of the result of the quantitative inversion model for trace element compositions of lava from Voyampolsky volcano in N-SR.

Most of the trace elements compositions of the Quaternary N-SR lavas can be reproduced by our quantitative inversion model assuming mantle flux melting by supplying slab-derived fluid (Fig. 2, Nishizawa et al., 2017). In the model, we calculated the fluid composition by using a partition coefficient between fluid and rock (Kogiso et al., 1997) and composition of the subducting slab. We assumed the composition of the altered oceanic crust of Pacific Plate (Kelley et al., 2003) and Meiji and Detroit seamount of the Emperor Seamount Chain (Regelous et al., 2003; Huang et al., 2005) as the composition of the subducting slab and the depleted MORB source mantle (DMM, Workman and Hart, 2005) in the wedge. The estimated melting condition of N-SR lavas are; degree of melting = 5–14%, fluid content = 1–4.5%, melting temperature = 1050–1150°C, these values do not show clear spatial changes, which indicates relatively homogeneous melting conditions of N-SR lavas. The slab-derived fluid is distributed even in the north beyond the subducting Pacific slab edge, which implies that the forearc slivers are subducting beneath N-SR.

References

Dorendorf, F., Wiechert, U. & Wörner, G. Hydrated sub-arc matnle: a source for the Kluchevskoy volcano, Kamchatka/Russia, *Earth and Planetary Science Letters* **175** 69–86, 2000.

Huang, S., Regelous, M., Thordarson, T. & Frey, F.A. Petrogenesis of lavas from Detroit Seamount:

Geochemical differences between Emperor Chain and Hawaiian volcanoes, *Geochemistry, Geophysics, Geosystems* **6**, 2005.

Kelley, K.A., Plank, T., Ludden, J. & Staudigel, H. Composition of altered oceanic crust at ODP Site 801 and 1149, *Geochemistry, Geophysics, Geosystems* **4**, 2003.

Kogiso, T., Tatsumi, Y. & Nakano, S. Trace element transport during dehydration processes in the subducted oceanic crust: 1. Experiments and implications for the origin of ocean island basalts, *Earth and Planetary Science Letters* **148**, 193–205, 1997.

Lay, T., Ye, L., Cheung, K.F., Kanamori, H., Freymueller, J., Steblov, G.M., Kogan, M.G. Rupture Along 400 km of the Bering Fracture Zone in the Komandorsky Islands Earthquake (Mw 7.8) of 17 July 2017, *Geophysical Research Letters* **44**, 12,161–12,169, 2017.

Nishizawa, T., Nakamura, H., Churikova, T., Gordeychik, B., Ishizuka, O., Haraguchi, S., Miyazaki, T., Vaglarov, B.S., Chamg, Q., Hamada, M., Kimura, J-.I., Ueki, K., Toyama, C., Nakao, A. & Iwamori, H. Genesis of ultra-high-Ni olivine in high-Mg andesite lava triggered by seamount subduction, *Scientific Reports* **7**, 2017.

Pevzner, M.M., Holocene Volcanism of Northern Kamchatka; The Spatiotempral Aspect, *Doklady Earth Sciences* 409A, 884–887, 2006.

Portnyagin, M. & Manea, V.C. Mantle temperature control on composition of arc magmas along the Central Kamchatka Depression, *Geology* **36**, 519–522, 2008.

Portnyagin, M., Hoernle, K., Avdeiko, G., Hauff, F., Werner, R., Bindeman, I., Uspensky, V. & Garbe-Schönberg, D. Transition from arc to oceanic magmatism at the Kamchatka-Aleutian junction, *Geology* **33**, 25–28, 2005.

Regelous, M., Hofmann, A.W., Abouchami, W. & Galer, S.J.G. Geochemistry of lavas from the Emperor Seamounts, and the geochemical evolution of Hawaiian magmatism from 85 to 42 Ma, *Journal of Petrology* **44**, 113–140, 2003.

Volynets, A.O., Churikova, T.G., Wörner, G., Gordeychik, B.N. & Layer, P. Mafic Late Miocene-Quaternary volcanic rocks in the Kamchatka back arc region: implications for subduction geometry and slab history at the Pacific-Aleutian junction, *Contributions to Mineralogy and Petrology* **159**, 659–687, 2010.

Workman, R.K. & Hart, S.R. Major and trace element composition of the depleted MORB mantle (DMM), *Earth and Planetary Science Letters* **231**, 53–72, 2005.

Yogodzinski, G.M., Lees, J.M., Churikova, T.G., Dorendorf, F., Woener, G. & Volynets, O.N. Geochemical evidence for the melting of subducting oceanic lithosphere at plate edges, *Nature* **409**, 500–504, 2001.