Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

*Tatsuji Nishizawa[1], Hitomi Nakamura[2,3,4,5], Tatiana Churikova[6,7], Boris Gordeychik[6,8], Maria Pevzner[9], Osamu Ishizuka[2,10], Hikaru Iwamori[3,4,11]

1. Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2. Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4. Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5. ORCeNG, Chiba Institute of Technology, 6. GZG, Abt. Geochemie, Universität Göttingen, 7. Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8. Institute of Experimental Mineralogy, Russian Academy of Sciences, 9. Geological Institute, Russian Academy of Sciences, 10. R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11. Earthquake Research Institute, The University of Tokyo

Marginal parts of a subducting slab and plate can play important roles in geodynamics. For example, the strength for plate boundaries affects the driving stress of the plates and especially spin motion of relatively small plate without slabs (Matsuyama and Iwamori, 2016), slab-derived fluid from subducted aseismic slab edge is distributed beyond the seismically determined edge and contributes the arc magmatism (Nakamura et al., 2018), and mantle flow around slab edge and corner flow in a mantle wedge could generate toroidal and poloidal components in the mantle convection (Yogodzinsky et al., 2001). The northwestern edge of Pacific (PAC) Plate, the largest oceanic plate on Earth, is subducting beneath Kamchatka, which forms a massive volcanic arc consisting of three subparallel volcanic belts: the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD) and the Sredinny Range (SR). The northwestern edge of PAC Plate has great influences on the geodynamics of Kamchatka-Aleutian junction but many parts of this region remain unexplained. Examples include arc magmatism in the north beyond the junction and inconsistency between petrological determined thermal structure of the wedge mantle and tectonically determined mantle flow direction (e.g., Yogodzinski et al., 2001; Portnyagin et al., 2005; Portnaygin and Manea, 2008).

We investigated the northern part of SR (N-SR) from N58°05’ and up to N58°38’ located north beyond the seismically determined PAC slab edge and found several the Quaternary-age fresh lava flows, young monogenetic cones and stratovolcanoes formed on the old basement rocks of plateau lavas. The N-SR lavas are classified as medium-K series basalt to andesite and show typical arc signatures with strong but variable LILE and LREE and low HFSE concentration, which indicates that fluid components have been supplied to the area where a subducted slab is not detected seismically. The fluid components could have been derived from the lower crust and/or lithospheric mantle or aseismic subducted slab (e.g., Volynets et al., 2010; Nekrylov et al., 2018). Compared with the volcanic front lavas of EVF and the Klyuchevskoy Volcanic Group located in CKD, the N-SR lavas have relatively high Nb and Ta contents. Such arc lavas with high Nb and Ta contents have also been reported from the Quaternary southern part of SR (S-SR) (e.g., Volynets et al., 2010; Nekrylov et al., 2018) and Nachikinsky and Hailula volcanoes in the northernmost part of CKD (N-CKD) (Portnyagin et al., 2005), where have the common point that an active Wadati-Benioff zone of the PAC slab is not observed underneath (Gorbatov et al., 1997).

On the other hand, we found a left-lateral strike-slip fault crossing N-SR in NW-SE direction and also found several similar faults in the south side of N-SR. These faults seem to have formed when southeastward trench retreat accompanied with slab rollback occurred due to a recent collision of the “Kronotski Arc terrain” with Kamchatka during 7 to 2 Ma, which extinguished the northern part of the older subduction zone and formed the modern subduction structure (Lander and Shaprio, 2007; Volynets

et al., 2010). However, according to the focal mechanisms of the earthquakes that occurred at the northern continental boundary of the Bering (BER) Plate, the BER Plate rotates clockwise about the rotation pole located at 67˚N, 176˚E (Gordeev et al., 2015). This model suggests that the BER Plate is still subducting from the northern old trench and its convergence rate decreases toward the north, which is consistent with the observation that the number of young (Quaternary) volcanoes in N-SR decreases toward the north. Therefore, the subducted aseismic BER slab beneath N-SR supplied the fluid components to the mantle wedge and caused the arc magmatism in the north beyond the seismically determined PAC slab edge. Two processes can be responsible for supplying a fertile mantle component with high Nb and Ta contents to the northernmost part and backarc area of Kamchatka: 1) a toroidal flow around the northern PAC slab edge and 2) mantle flow from the NW due to the slab rollback in SE direction.

Keywords: slab edge, Pacific Plate, Kamchatka

