GEOCHEMISTRY AND MINERALOGY OF THE LATE PLEISTOCENE OLD SHIVELUCH VOLCANO, KAMCHATKA

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Shiveluch is one of the largest and most active volcanic centers in Kamchatka, located at the Kurile–Kamchatka and Aleutian arc junction. This complex volcanic massif includes the Late Pleistocene partially destroyed by a sector collapse Old Shiveluch stratovolcano and Young Shiveluch eruptive center, which has been active through the Holocene (Melekestsev et al., 1991). Due to the unique geodynamic setting and the occurrence of magnesian andesites among erupted products (Volynets, 1997; Ponomareva et al., 2007), the origin and evolution of Shiveluch Volcano is of high importance for the modern models of magma generation in Kamchatka. Petrological and geochemical studies (Volynets et al., 1997; Ponomareva et al., 2007; Portnyagin et al., 2007; Gorbach Portnyagin, 2011) has mainly focused on the products of the Young Shiveluch. A few attempts only (Menyailov, 1955; Melekestsev et al., 1991; Ferlito, 2011) have been made to obtain information about the Late Pleistocene geochemical evolution of the volcano. Here we report results of a detailed field geological study of the Old Shiveluch volcanic edifice and geochemical and mineralogical investigation of the volcanic rocks .

At the base of the Old Shiveluch we mapped a thick sequence of andesitic agglomerate and psephitic tuffs related to the initial extrusive and explosive Shiveluch activity. Stratigraphically younger Old Shiveluch lava complex is related to four distinct eruptive centers, which produced mainly andesitic and basaltic andesitic lava flows and minor pyroclastics. Three main type of rock were distinguished in the Old Shiveluch volcanic edifice: volumetrically dominant magnesian andesites (SiO_2=57.3-63.8, Al_2O_3=16.5-17.6, MgO=2.8-4.8, K_2O=1.2-1.7 (wt.%), Mg#=52.5-57.0 mol. %.), high-Al basaltic andesites (SiO_2=53.5-55.7, Al_2O_3=16.6-17.5, MgO=4.4-5.9, K_2O=0.9-1.2 (wt. %), Mg#=52.1-56.1 mol%) and small volume high-Mg basaltic andesites (SiO_2=53.9-55.0, Al_2O_3=15.1-16.5, MgO=6.1-7.5, K_2O=1.2-1.3 (wt.%), Mg#=58.8-63.7 mol.%). All studied rocks belong to the medium-K calc-alkaline series and exhibit strong enrichment in incompatible elements (Cs, Rb, Ba, K, Pb, Sr, U and Th) and depletion in HREE (e.g., Portnyagin et al., 2007).

Major and trace elements concentrations in the Old Shiveluch rock series correlate well and indicate that all Old Shiveluch rocks are likely genetically related to each other. With decreasing MgO content, concentrations of incompatible lithophile elements (e.g., Ba, K, Th) increase and concentrations of compatible trace elements (e.g., Cr, Ni) decrease in the rock series. This suggests the dominant role of fractional crystallization at creating the diversity of the Old Shiveluch rocks. At given Mg#, the high-Al basaltic andesites have higher Al_2O_3 and lower SiO_2 than typical Old Shiveluch andesites. Incompatible trace element concentrations and their ratios are, however, similar in both rock types and imply the existence of a common parental melts for the Old Shiveluch. The observed diversity of the evolved rocks can be related to variable conditions of crustal evolution of mantle-derived magmas beneath Shiveluch. Similar REE patterns and incompatible trace elements ratios (e.g. Zr/Y, La/Yb, Ba/Th, Ba/La, Th/La, Th/Yb) of high-Mg and high-Al basaltic andesites also indicate their origin from a common parental melts.

Petrographic and mineralogical data for different Old Shiveluch rock types indicate long and multi-stage crystallization history of the magmas at the different crustal levels. Compositions of olivine in high-Mg basaltic andesites are bimodal with the majority of compositions falling at Fo_{90-92} and Fo_{86-88}. The composition of rare olivine in high-Al basaltic andesites is similar to phenocrysts rims (Fo_{82-84}) of high-Mg rocks. The compositions of clinopyroxene phenocrysts are very similar

(Mg# =74-88) in all rocks types. Some samples of the Old Shiveluch magnesian andesites contains Al-rich high-pressure amphiboles which coexist with Al-poor, low-pressure hornblendes in the same samples.

Both mineralogical and whole-rock geochemical data suggest that the occurrence of high-Mg and high-Al basaltic andesites in the Old Shiveluch volcano is most likely related to different pressure conditions of magma evolution rather than to different and spatially separated deep magma sources in the mantle and subducting slab, which have been proposed for Shiveluch volcanic massif in some recent models (e.g., Ferlito, 2011).

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