Petrology of pumice stone in the 39 ka caldera-forming eruption of Mendeleev volcano (Kunashir Island)

Alexey Kotov[1]*, Sergey Smirnov[2], Noriyoshi Tsuchiya[1], Masaoki Uno[1]
([1]Graduate School of Environmental Studies, Tohoku University, [2]Institute of Geology and Mineralogy, Siberia Branch, Russian Academy of Sciences, Novosibirsk)

Caldera eruption of Mendeleev volcano occurred about 39 thousand years ago on Kunashir Island. The volume of pyroclastic material is estimated at 60 km^3, which makes this eruption one of the largest eruptions of the Upper Pleistocene in the Southern Kuril Islands.

The pumice stones of the caldera eruption are dacitic. The proportion of porphyry phenocrysts in pumice is not higher than 20 vol. %. Phenocrysts are represented by plagioclase, augite, hypersthene, quartz, magnetite, and ilmenite, immersed in glassy groundmass. Amphibole was found only in the form of crystalline inclusions in pyroxenes. Amphibole is Mg-Fe^{3+} hornblende (Al_2O_3 7 - 11 wt. %). To estimate pressures, we used an amphibole geobarometer (Ridolfi et al., 2010). We argue that the amphibole is a relic of a mineral association which formed during the partial melting of crustal metabasites of Kunashir Island. Thus, the estimates of the PT parameters correspond to the process of generation of the melt that participated in the formation of the upper crustal magmatic chamber. The maximum estimates of the PT parameters were about 3 kbar and 920°C. Most of the compositions of amphibole correspond to 1-2 kbar and temperatures of 780 - 890°C. Melts were formed at high fO_2 corresponding to the NNO +0.1-1.9 buffer.

Pumice phenocrysts often contain primary glassy melt inclusions (MI). Sometimes these MI's contain empty shrinkage bubbles. The composition of MI corresponds to low-K_2O dacite-rhyodacite. MI's differ from the bulk rocks by a higher SiO_2 content and do not differ in alkali content. The most important part of this study is to determine the content of volatile components in the melts that participated in the caldera eruption. By combining the methods of Raman spectroscopy and the measurement of oxygen by the EMPA EDS, we found that MI's contain from 4.2 to 7.4 wt. % H_2O. At the same time, the water content in the glass of the groundmass does not exceed 4.5 wt% H_2O, which indicates significant losses of volatile melts during a caldera eruption. Comparison of the content of volatile components in glasses of the groundmass and in melt inclusions allows us to estimate the amount of volatile components emitted into the atmosphere during a caldera eruption.

Phenocrysts of plagioclase and clinopyroxene also contain primary and pseudo-secondary fluid inclusions (FI). The features of the composition and location of FI's show that during the evolution the melt degassed. And this degassing is not associated with the final large eruption, as indicated by the presence of pseudo-secondary FI. Also, combined melt inclusions were found. They are represented by melt, trapped non-daughter crystals and two-phase fluid segregations (liquid H_2O and gaseous CO_2). These inclusions indicate that the fluid pressure in the chamber could have exceeded the lithostatic one. An additional drop in lithostatic pressure (for example, due to the rise of magma) allowed additional portions of fluid to migrate from the glass of the melt inclusion into these segregations. The data obtained make it possible to accurately describe the evolution of magma from Mendeleev volcano before the caldera eruption and to compare it with other Pleistocene-Holocene calderas of the Southern Kuriles.

References

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*Corresponding author: kotov.alexey.s1@dc.tohoku.ac.jp