Millennium-scale major element variations of Klyuchevskoy volcano magmas (Kamchatka) revealed from high-resolution study of tephra deposits

Portnyagin M., Ponomareva V., Bindeman I., van den Bogaard C., Kuvikas O., Krasheninnikov S., Mironov N., Plechova A., Hoernle K.

Klyuchevskoy volcano in the Central Kamchatka Depression has average annual magma output ~9 million tons and is believed to be the most productive arc volcano on Earth. Here we report preliminary results of study aimed at deciphering of chemical evolution of Klyuchevskoy volcano and focused on tephra deposits, which provide an unprecedentedly detailed and age-controlled record of the volcano activity since early Holocene. About 100 individual layers of dark-gray Klyuchevskoy cinders and 23 light-colored dominantly silicic marker tephra layers from large explosive eruptions of other volcanoes were collected from two tephra sections ~15 km northeast of the Klyuchevskoy volcano summit. Identification of regional marker tephras, dated elsewhere, in our sections has allowed us to time Klyuchevskoy samples with an accuracy of 50-100 years.

Volcanic glass in all samples, minerals and several bulk tephra samples were analyzed for major and trace elements. An intriguing result from these data is that glass compositions and extent of Klyuchevskoy magma fractionation exhibit wave-like variations through time. Despite some short time-scale variability, major compositional cycles are clearly identified through the volcano life-time with a period of ~3-4 ka. Minimum extent of melt fractionation is observed at ~9, 6 and 3 ka BP. Maximum fractionation took place at 7.5 and 4 ka BP and is approaching in the historic time. Between these extremes, glass compositions change gradually from relatively primitive basaltic to andesitic and dacitic. Preliminary, we interpret these compositional variations as reflecting millennium-scale variations in magma supply from the mantle to magma-feeding system beneath Klyuchevskoy volcano. In the continuously recharging shallow magma reservoir, evolving magmas likely approach higher degrees of fractionation at low supply of primitive magma from the mantle and vise versa, erupted magmas are less fractionated at high primitive magma supply. Although more plausible explanation should not be excluded to result from the ongoing research, these data demonstrate that detailed analysis of well-dated tephra sections may be helpful to decipher dynamics of magma chamber processes and, possibly, variations in magma supply from the mantle to crust on a scale of hundred to thousand years.