



## The petrological relationship between Kamen volcano and adjacent volcanoes of Klyuchevskaya group

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The Klyuchevskaya Group (KG) of volcanoes has the highest magma production rate across the Kamchatka arc and in fact for any arc worldwide. However, modern geochemical studies of Kamen volcano, which is located between Klyuchevskoy, Bezymianny and Ploskie Sopky volcanoes, were not carried out and its relation and petrogenesis in comparison to other KG volcanoes is unknown. Space-time proximity of KG volcanoes and the common zone of seismicity below them may suggest a common source and genetic relationship. However, the lavas of neighboring volcanoes are rather different: high-Mg and high-Al basalts occur at Klyuchevskoy volcano, Hbl-bearing andesites and dacites dominate at Bezymianny and medium-high-K subalkaline rocks at Ploskie Sopky volcano. Moreover, previously it was shown that distinct fluid signatures were observed in different KG volcanoes. In this report we present geological, petrographical, mineralogical and petrochemical data on the rocks of Kamen volcano in comparison with other KG volcanoes.

Three consecutive periods of volcano activity were recognized in geological history of Kamen volcano: stratovolcano formation, development of a dike complex and formation of numerous cinder and cinder-lava monogenetic cones. The rock series of volcano are divided into four groups: olivine-bearing (Ol-2Px and Ol-Cpx), olivine-free (2Px-Pl, Cpx-Pl and abundant Pl), Hb-bearing and subaphyric rocks. While olivine-bearing rocks are observed in all volcanic stages, olivine-free lavas are presented only in the stratovolcano edifice. Lavas of the monogenetic cones are presented by olivine-bearing and subaphyric rocks. Dikes are olivine-bearing and hornblende-bearing rocks. Olivines of the Kamen stratovolcano and dikes vary from Fo60 to Fo83, clinopyroxenes are augites in composition and plagioclases have a bimodal distribution with maximum modes at An50 and An86. Oxides are represented by high-Al spinel, magnetite and titaniferous magnetite. Mineral compositions of the rocks from monogenetic cones are systematically different from minerals of dikes and stratovolcano. Olivines in monogenetic cones varies from Fo70 to Fo92, Mg# of clinopyroxenes from 72 to 80 and plagioclases are represented by An60-80.

All rocks of the volcano belong to medium-K calc-alkaline basalt-basaltic-andesitic series. The rocks of the stratovolcano are high-Al low-Mg ( $\text{MgO} \leq 7\%$ ,  $\text{SiO}_2 \sim 50 \div 56\%$ ) and form the stable trends on all petrological diagrams with increasing K<sub>2</sub>, decreasing Al<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, CaO, FeO and MgO from basalts to andesites. The melts of the dike complex are likely the least fractionated members of the same mantle source which is confirmed by the same mineral composition. Lavas of the monogenetic cones are high-Mg basalts ( $\text{MgO} > 6\%$ ,  $\text{SiO}_2 \sim 50.5 \div 52.5\%$ ). They systematically differ from the stratovolcano samples by mineral composition and by higher MgO and CaO and low FeO, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> and P<sub>2</sub>O<sub>5</sub> at similar SiO<sub>2</sub> content.

The rocks of Ploskie Sopky volcano are systematically different from stratovolcano Kamen in major elements and mineral composition and thus can not originate from the same mantle source by fractional crystallization. In contrast Kamen and Bezymianny stratovolcanoes form the narrow single geochemical trends, where Bezymianny data points comprise a more silica-rich part of the overall trend. Klyuchevskoy high-Mg cinder cones are similar to cinder cones of Kamen. However, Klyuchevskoy stratovolcano rocks differ in major elements and mineral composition from dikes and stratovolcano of Kamen.

Thus, using petrological and mineralogical data we conclude that (1) Kamen and Bezymianny volcanoes have a common source; (2) monogenetic cones, which were erupted at Kamen volcano, belong to the group of high-Mg cones of Klyuchevskoy.