THE ORIGIN AND COMPOSITION OF PRIMITIVE MELTS OF KLYUCHEVSKOY VOLCANO, KAMCHATKA - INSIGHT FROM MELT INCLUSIONS STUDY

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Klyuchevskoy volcano is one of the largest and most productive volcanoes in the world. It is located in the Central Kamchatka Depression on Kamchatka peninsula - a part of Kurile-Kamchatka island arc. Age of volcano is about 7 thousand years. Volcanic products are represented by series of high magnesia to high alumina basalts. To obtain information about the composition of primitive melts and conditions of their generation, there were studied melt inclusions in olivine phenocrysts (Fo_{91-89}) from different Klyuchevskoy basalts (high magnesian basalts of Bulochka and Luchitskii cones, magnesian basalts of Ochki and Tuyla flows and high alumina basalt of Apakhonchich flow) erupted in the last 4000 years. Most of melt inclusions were partially crystallized so they were experimentally reheated. For this purpose heating stage with visual control of Sobolev-Slutsky construction [1] was used. The inclusions were partially homogenized (melt + fluid phase) and quenched. Small part of studied inclusions was represented by naturally quenched inclusions, consisting of glass and gas bubble. For major elements all glasses were analysed by microprobe, for trace elements and water - by SIMS. Analysed compositions were corrected using method [2] considering re-equilibration of inclusions with their host. Initial FeO content in melts was assumed 8.5 wt.% corresponding to average FeO content of Klyuchevskoy rocks. The pressure of crystallization was determined using temperature difference for Ol-Cpx cotectic [3], temperature-using Ol-melt thermometer [4]. Temperature was corrected for pressure (5 °C/kbar) and for water content (2-2.5 wt. % - dT=100 °C [5]). Melt oxidation state was estimated using composition of Cr-spinels trapped in olivines as crystal inclusions [6], [7]. The most primitive melts start to crystallize at pressure 1.5 GPa, temperature 1300 °C and oxygen fugacity close to NNO buffer. Average composition of the melts is (in wt.%): SiO_2=47.9, TiO_2=0.8, Al_2O_3=15.5, FeO_{tot}=8.5, MgO=10.7, CaO=12.8, Na_2O=2.8, K_2O=0.6, P_2O_5=0.13, S=0.2, Cl=0.1, F=0.034. Wide variations were found for H_2O content (0-2.5 wt.%). Minimum CO_2 content was estimated to be 0.4 wt.% from the density of CO_2 – rich fluid inclusions in olivine Fo_{88}.

Despite general similarity, the melts trapped in high-Mg olivines show variable SiO_2, Al_2O_3, CaO, Na_2O и H_2O content. All primitive melts were divided by water content into two groups: low water (LW) - with H_2O content less then 1 wt.% - and high water melts (HW) - H_2O content more then 1 wt.% and were calculated to equilibrium with Fo_{91}. Negative (SiO_2-CaO, SiO_2-Al_2O_3) and positive (Na_2O-Al_2O_3) correlations are observed between SiO_2, Al_2O_3, CaO and Na_2O content so that H_2O-rich melt inclusions tend to show higher SiO_2 and lower Al_2O_3, CaO and Na_2O compared with H_2O-poor inclusions (fig.1).

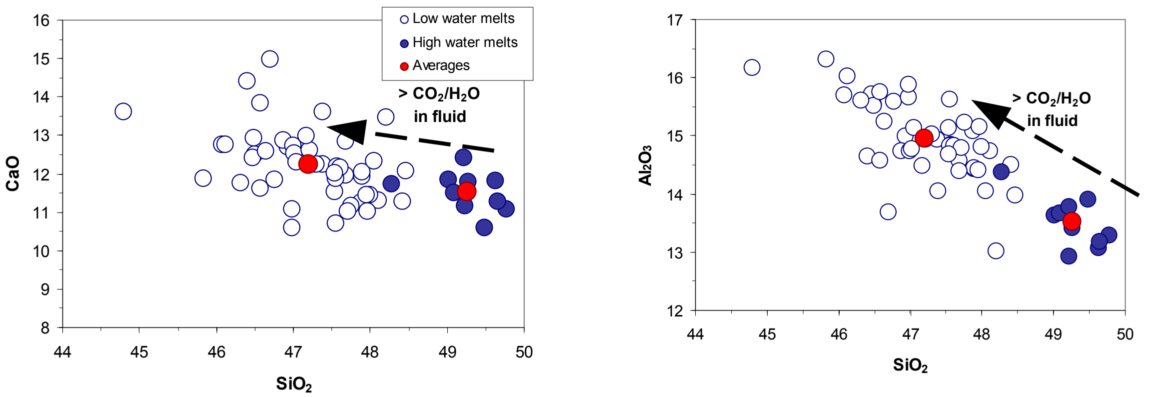

Fig.1. Variations in primary melt compositions. Low water, high water melts and their averages are shown. The correlations can be explained by variations of CO_2/H_2O in fluid during melts formation. All compositions are

calculated to 100 %, without water.

In average HW melts are Hyp-normative and LW melts are Ne-normative. Observed variations can't be explained by assimilation of Pl or (and) Cpx. Equal trace element contents for HW and LW melts averages show that melts were formed at similar degrees of melting. We suggest that the variations in primitive melt compositions were produced in the mantle source melted in presence of subduction derived fluid with variable CO_2/H_2O ratio. The higher was CO_2 activity in the fluid, the more compositions of partial melts were shifted toward nepheline- and larnite-normative field with higher Al_2O_3, CaO, Na_2O and lower SiO_2 compared to melts produced at low CO_2/H_2O ratio in the fluid. It is likely that water content in all primary melts was high (2-2.5 wt.%), corresponding to maximum measured concentrations in glasses of inclusions. It seems truth that inclusions from LW group were strongly affected by water loss process after their entrapment. Perhaps it was higher CO_2 activity that favoured such process. Absence of plagioclase in early mineral assemblage also indicates to high initial water content.

Primitive Klyuchevskoy rocks-magnesian basalts with MgO=9.7-12.2 wt.% - differ from primitive melts trapped in early olivines by higher SiO_2 (51.5 wt.%), lower Al_2O_3 (13.8 wt.%) and CaO (9.7 wt.%) content. Such a difference can be explained if these rocks have an origin by cumulation of magnesium Cpx and Ol in evolved melts, similar to high alumina basalts [8].

Mass-balance calculations show that cumulation of 9 % of Ol, 20 % of Cpx ans 3 % of Sp in high alumina melt can lead to formation of rock corresponding in composition to high magnesian basalt (HMB). Observation on real occurrence of Ol and Cpx phenocrysts in HMB (12 % of Ol and 5 % of Cpx) shows less Cpx content in comparison with calculated value. This can be explained by considerable dissolution of Cpx during magma ascent.

In summary, the observed difference between host rocks and melt inclusions of Kluchevskoy volcano calls into question representativity of the rocks as samples of magmatic liquids. It is possible that similar complex processes of magma fractionation occur in many arcs over the world. In this case, melt inclusions can provide more careful and precise insight into the chemistry and origin of primitive arc melts.

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