Low-SiO_2 melt inclusions in olivine originate by dehydration of initially H_2O-rich island-arc melts

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The majority of melt inclusions (MIs) reported in olivine Fo>88 mol% from island-arcs have SiO_2-undersaturated compositions, which are distinctive from those of predominantly SiO_2-saturated primitive (Mg#>0.65) island-arc rocks. A number of models has been proposed to explain the origin of these MIs. All the models suggested that low-Si melts existed in nature and were preserved in MIs. In this work we propose an alternative hypothesis implying that these MIs do not represent large volume natural melts but originate by post-entrapment modification of initially SiO_2-saturated MIs.

We show that experimental hydration of SiO_2-undersaturated MIs in olivine Fo_{85-90} from Klyuchevskoy volcano in Kamchatka at 300 MPa pressure and 1200 ºC causes a concomitant enrichment of melt in H_2O and SiO_2 so that re-hydrated MIs (4-5 wt% H_2O) become as SiO_2-saturated as primitive Klyuchevskoy rocks. A reverse process occurs for experimental dehydration and results in coupled depletion of melt in H_2O and SiO_2. The estimated H diffusivity, FTIR spectra of de- and hydrated olivines and the stoichiometry of coupled Si and H loss/gain suggest hydrogen diffusion in the octahedral metal (Mg, Fe) vacancies in olivine and crystallization of metal-defect olivine (MgH_2SiO_4 and/or $FeHSiO_4$) on MI walls during melt dehydration or reverse process of defect olivine dissolution during melt hydration.

We conclude that the previously reported SiO_2-undersaturated compositions of many MIs from island-arc rocks can originate by dehydration of the initially trapped primitive SiO_2-saturated H_2O-rich melts. Our results show that the initial H_2O content of 5-6 wt% may be typical for island-arc magmas, in contrast to the results based on direct determination of H_2O in potentially dehydrated MIs. The higher H_2O in primary arc melts implies the existence of a 'crustal filter' controlling the water content which can be preserved in melt inclusions.