H2O concentration in primary arc magmas estimated by experimental petrological studies and analyses of melt inclusions

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The slab-derived fluids and/or hydrous slab melts released from a subducted slab hydrate the mantle wedge, lower its melting temperature and induce generation of hydrous arc magmas. Experimental petrological studies have clarified that the H2O shift pressure and temperature conditions of magma generation at subduction zones (Tatsumi et al., 1983 JGR), and thus it is critical to estimate H2O concentration in primary arc magmas. We will give an overview on selected attempts to estimate H2O concentration in primary arc magmas by experimental petrological studies and analyses of melt inclusions in recent 30 years. Melting experiments of hydrous primary arc magmas by Pichavant et al. (2002 GCA) demonstrated that only primary magmas with low H2O (< 2 wt.%) can erupt without modification of their primary composition by crystallization differentiation due to comparable dP/dT between olivine liquidus and basalt adiabat. These constraints do not exclude presence of hidden H2O-rich primary magmas. Indeed, the H2O concentration in primary magma estimated from the analyses of primitive melt inclusions suggest wide variation (e.g., 2 wt. % at Kamchatka arc and 4 wt. % at Central American arc). H2O-rich primary magmas may ascend and erupt after differentiation and/or supply volatiles to magmas at shallower level and cause so-called “excess degassing”.

The H2O concentration in primary magmas can be variable not only among different arcs and/or volcanoes, but also in a single arc volcano: both H2O-rich and H2O-poor primary magmas can coexist. This idea has been proposed by many petrologists to explain coexistence of tholeiitic series rocks and calc-alkaline series rocks in a single arc volcano since Kuno (1950). Further studies on variation of H2O concentration in primary magmas, in combination with geochemical studies and numerical studies, will constrain genetic conditions of such dual primary arc magmas.

Keywords: H2O concentration in primary arc magma, Experimental petrology, Melt inclusion, Island arc magmatism, Subduction zone