Accumulation of water in the caldera-forming magmas of the Naruko volcano

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Naruko caldera was formed by two eruptions: the Nizaka pyroclastic flow (c. 72 ka) and the Yanagisawa pyroclastic flow (c. 45 ka). The pumice stones of both eruptions are rhyolites (K_2O 1.4-1.5 wt %). Total erupted volume around 12.5 km^3.
Volatile concentration in melt inclusion (MI) and groundmass glasses were measured using SIMS. MI in Yanagisawa phenocryst contain H_2O 4.5-5.0 wt %, CO_2 < 20 ppm, Cl 1.2-1.8 wt %, S <40 ppm. MI in Nizaka phenocryst contain H_2O 3.5-5.9 wt %, CO_2 <18 ppm, Cl 1.1-2.0 wt %, S <30 ppm. Using VolitileCalc (Newman and Lowenster, 2002) and amphibole geobarometry (Ridolfi and Renzulli, 2012) we estimated pressure of 1.0-2.3 kbars. This pressure corresponds to shallow magma chamber conditions (2.5-5.5 km depth). Based on Opx-Liquid and Fe-Ti oxides thermometry, and MI' s homogenization experiments, the temperature of magma was estimated of 830-870˚C for both eruptions. Thus, we can conclude that dacite magma took place at range of depths of ~2.5–5.5 km. Magma temperature was 830-870˚C. H_2O content in the rhyolitic melt of 3.5–6.0 wt %.
Taking that the diameter of the magma chamber equal to the distance between caldera rims (7 km) and that the thickness of the magma chamber equal to 3 km (between 2.5-5.5 km) we estimate the volume of upper crustal rocks wherein magma took place (magma chamber in a broad sense) could be equal to 115 km^3, and around 12.5 km^3 (10.8 vol %) has erupted. The total amount of H_2O stored in the chamber (dissolved in the melt) is $7.5x10^{11}$-$1.2x10^{12}$ kg. Using the difference in water content between MI and groundmass glass we estimated the total loss of water due to melt degassing during an eruption of $3.7\text{-}9.0x10^{11}$ kg (50-70 wt %).
Taking that the time difference between two eruptions is 27ka, we estimated total water input into the chamber during this time relatively to arc length. In this case, we roughly assume that magma accumulated during this time was erupted in full at the end. Such estimates of the time are very rough and probably provide the minimum estimates. Based on the above, we calculated the H_2O input into the upper crust of 3.2-5.5 t/year/m. (Kimura and Nakajima, 2014) estimated the total water flux into the crust in the NE Honshu subduction zone is 13 t/yr/m. Regarding this data, we conclude that 25-42 % of all input water from the mantle to the crust can be accumulated in upper-crustal high-SiO_2 melts.

Keywords: Caldera eruptions, Water content, Water flux

