Unprecedented sulfur and halogen emissions during the 1257 A.D. Samalas eruption (Rinjani volcanic complex, Indonesia)

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The 1257 A.D. caldera-forming eruption of Samalas (Lombok, Indonesia) was recently associated with the largest sulfate spike of the last 2.3 ky recorded in polar ice cores [1]. This eruption provoked a global cooling over land of -1.3°C to -2.7°C over 4-5 years [2]. Detailed analysis of the stratigraphy and quantification of the eruptive dynamics suggested that the 1257 A.D. Samalas eruption stands as the most powerful event of the last millenium [3]. Major and trace element geochemistry of bulk erupted products and plagioclase-hosted melt inclusions shows that the 1257 A.D. trachydacite magma belongs to the Rinjani K-calc-alkaline suite, and more importantly that the eruption evacuated 40 km^3 of trachydacite at 990-1030°C from a geochemically uniform reservoir [64.2±0.5 SiO_2; 7.7±0.7 (Na_2O+K_2O), in wt% normalized on anhydrous basis], located in the upper crust. Evidence from the 1257 minerals, melt and fluid inclusions indicates that the magma was satured with Fe-bearing sulfides and in equilibria with a free (C)-O-H-S vapor phase prior to eruption. Mass-balance calculations provide a maximum sulfur partition coefficient $D_S^{fluid/melt}$ of 13, which fills a gap of experimental constraints for these magmatic conditions. The eruption released a total of 79±6 Tg of sulfur (158±12 Tg of SO_2), 227±18 Tg of chlorine and 1.3±0.3 Tg of bromine into the atmosphere. Vapor supply from the deeper parental basalt, if occurred, could have increased the sulfur budget by a factor of ~1.5. These prodigious sulfur, chlorine and bromine yields constitute the largest stratospheric volatile emissions over the last 2.3 ky. The efficiency of the plume to load volatiles up to 43 km in the stratosphere inferred from the study of the plume dynamics suggests that, besides the reported global impact on climate, the 1257 Samalas eruption may have generated substantial ozone destruction.

[1] Lavigne et al. (2013) *PNAS* 110(42):16742-16747. [2] Stoffel et al. (2015) *Nat Geosci* 8:784e788. [3] Vidal et al. (2015) *Bull Volcanol* 77(9):1-24.