

Behavior of fluorine and chlorine in the volcanic ash of the 2004 eruption of Asama volcano, Japan

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In eruption plumes, the pristine ash particles react with volcanic gases, which gives origin to the water-soluble components. Meanwhile, volatiles that are not exsolved from magma are tightly sealed within the ash particles in water-insoluble forms. Hydrogen fluoride (HF) and hydrogen chloride (HCl) are major constituents of high temperature volcanic gas, exclusive of water vapor. Further, F and Cl are the most abundant volatile components next to H₂O in volcanic rocks. Water-soluble and water-insoluble F and Cl contents and the F/Cl ratio of volcanic products are good indicators for fractionation processes of these volatile components on volcanic eruption.

Asama volcano lying in central Japan has repeated violent explosions over the centuries. Although vulcanian explosions frequently occurred in the 1930s and the 1940s, the volcanic activity certainly had become in descendent since the middle of the 1950s. After the magmatic eruption in 1958, the eruptions with ascending new magma occurred only in 1961, 1973 and 2004. The eruptive activity of Asama volcano in 2004 began with violent explosion and continued for about four months. The explosions were followed by non-explosive eruption with continuous tephra emission. After the non-explosive eruptions, Asama produced eighteen vulcanian explosions.

Volcanic ash discharged by the first explosion had extremely high contents of F and Cl in water-soluble and water-insoluble forms, which was attributed to reaction with volcanic gas containing HF and HCl with in the crater in the non-eruptive period prior to this eruption. F and Cl were stabilized onto the ash mainly in water-insoluble form and water-soluble form, respectively, and these were fractionated through the prolonged alteration during non-eruptive period before the explosion. On the strombolian eruptions, volatile-rich magma filled the conduit and produced the pristine ash particles continuously. HCl and SO₂ in gas phase were congruently fixed onto the ash particles. Meanwhile, HF and HCl in gas phase were incongruently stabilized onto the ash particles due to the difference in reactivity. During the vulcanian explosion phase, chlorine was intensely degassed from the effused lava by progression of crystallization of the effused lava, whereas fluorine was captured on the lava through reaction with volcanic gases. F is less volatile from magma and much reactive with volcanic ash than Cl, and thus not only degassing but also reaction with volcanic gas controlled volatile contents in volcanic ash.