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The 2010 Eyjafjallajökull volcanic summit eruption: evidences from ash-leachates analysis and ground deposition fluxes

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The Eyjafjallajökull 2010 eruption was an extraordinary event in that it led to widespread over Europe. Volcanic processes which lead to eruptions can be investigated by monitoring a variety of parameters, including the composition of ash leachates. Fine-grained tephra erupted from active vents, and transported through volcanic plumes, can adsorbs, and therefore rapidly scavenge, volatile elements such as S, halogens, and metal species in the form of soluble salts adhering to ash surfaces. Analysis of such water-soluble phases is a suitable complement for the remote sensing of volcanic gases at inaccessible volcanoes, like Eyjafjallajökull. The 2010 Eyjafjallajökull eruption developed in four main phases, whose difference in gas chemistry and products has been marked in ash-leachates data too. The recurrent ash fallout provided a unique opportunity to characterize the compositional features of ash leachates, and to identify their relation (if any) with the eruptive activity styles of the volcano. By these considerations, we report on the chemical composition of leachates of 20 volcanic ash samples deposited during the most explosive Eyjafjallajökull activities (from 14 April to 8 May) and during the lava fountaining event (on 26^{th} March 2010). We found that ash-leachate solutions are dominated - among cations - by Na and Ca, while they display nearly equal $S : Cl : F$ abundances (mean S/Cl and S/F molar ratios of 0.85 and 0.33, respectively), as characteristic of divergent-plate and within-plate volcanism. The strong correlations between leached $Ca - F$, $Ca - SO_4$, and $Na - Cl$ ($r^2 = 0.7 - 0.9$), suggest that fluorite, anhydrite, and halite are the most likely soluble surface minerals formed in the plume (and therefore leached during our experiments), as also reported at many active volcanoes. Our data bring evidence for variations in S and halogens proportions, with samples from $5 - 8^{th}$ May which show the highest S/Cl and lowest Cl/F ratios. By combining the concentration of leached SO_4, F and Cl with the mass/area ratio of deposited ash (normalized to 30 min of 5-8 May 2010 volcanic phase), we estimated mean depositional elemental fluxes of about 1.0×10^{-5}, 1.1×10^{-3} and 1.2×10^{-3} $g \cdot m^{-2} s^{-1}$, for the water-soluble SO_4, Cl and F, respectively. By integrating these data over the whole sampling area, we estimated a total depositional flux of about 864, 605 and 691 $t \cdot day^{-1}$, for SO_4, Cl and F, respectively. These data mean that $\sim$ 15% of S_{gas} and 29% of Cl_{gas} discharged into the plume during the same eruptive phase, may have been scavenged by adsorption processes on ash surfaces within the eruption column.