# The radioactivity of airborne volcanic ash

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Keywords: polonium-210, volcanic ash, atmospheric aerosol.
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In the wake of the eruption of the Icelandic volcano Eyjafjallajökull during spring 2010, and the wandering of its ash plume over Europe, responsible of an unprecedented disruption of air traffic, the potential health impact of the inhalation of volcanic "ashes" was questioned both in the news media and in the scientific literature. Among the hypothetical public-health effects at a long distance from the erupting volcano, those potentially induced by the radionuclide content of the ash particles were explicitly addressed (Mascarenhas and Mattoso, 2010). The natural radioactivity burden of the Eyjafjallajökull volcanic plume was even assumed to compare with the radioactive source-term of the Chernobyl (1986) nuclear accident…

If it is true that the primordial long-lived radionuclide content of one cubic kilometre of dense magma is in the few PBq range, and that the Pinatubo in 1991, as an example, erupted 5 $km^3$ of magma (probably the second largest volcanic eruption of the last century), most of the radioactivity falls on the ground close to the volcano where it covers a ground with roughly the same composition. Only a minute fraction of the erupted material (the so-called "ash inhalable fraction") remains airborne and shares the fate of the tropospheric (and sometimes stratospheric) aerosol. The clearly identified respiratory health hazard of high concentration volcanic ash (Horwell and Baxter, 2005) does not stem from its intrinsic radioactivity content.

On the other hand, during the eruptive process, and ash formation from vesiculation of the ubiquitous $^{238}U$-containing magma, radon long-lived decay products, which can reach secular equilibrium in the magma chamber, are readily adsorbed at the surface of particulate mater. Due to its volatility, this is particularly true for polonium-210: it turns out that this radionuclide (half-life 138 days) is a powerful atmospheric marker of volcanism. Indeed, half of the natural polonium-210 we inhalate is of volcanic origin (Lambert *et al.*, 1979).

In a prospect of "nuclear forensics" aiming to identify the source of any anomalous (*i.e.* above background) airborne radioactivity, the outstanding concentration of polonium-210 as an alpha emitter in the atmosphere (of the order of 0.1 $mBq/m^3$) can be used to the best advantage for establishing a baseline. Hence, this can be done through a relatively straightforward routine measurement of the atmospheric aerosol global-alpha activity. Should a particular event (either natural or man-made) occur, the burdensome radiochemical analysis of the sampling filters can then fill the uncertainty gap.

Preliminary $^{210}Po$ determinations were performed in 2013 from aerosol samples collected near Paris, France. We also took the opportunity of the Bárðarbunga volcano eruption (in September 2014) to check for a possible intrusion of volcanic ashes and vertical spreading down to the ground level. It is generally assumed that the $^{210}Po/^{210}Pb$ ratio is close to 0.1 over continental areas (Kim *et al.*, 2000). An average $^{210}Pb$ of 450 $\mu Bq/m^3$ derived from weekly aerosol samplings in France over the last decade, was found. Thus, a $^{210}Po$ concentration of ~ 45 $\mu Bq/m^3$ was expected. We observed a wide variability of the airborne $^{210}Po$ concentrations (8-2500 $\mu Bq/m^3$). The lower values were obtained in February and refer to a background status.

During the Bárðarbunga plume arrival (22-29 September), the $^{210}Po$ activity concentration did not exhibit very high values (160 $\mu Bq/m^3$). These weak polonium concentrations were tentatively inferred from low ($^{210}Po/^{210}Pb$) in the gas emission (Gauthier *et al.*, 2016). They also coincide with comparatively high $SO_2$ concentrations. Apart from the volcanic activity, polonium-210 can originate as well from biomass burning (Paatero *et al.*, 2009), soil re-suspension, domestic heating systems and local coal power plants (Długosz-Lisiecka, 2015). Our highest $^{210}Po$ values did not match with high $SO_2$ or $^{210}Pb$ concentrations and are likely to result from one of these non-volcanic sources.

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