# The ash that closed Europe's airspace: Part II, the physical aspects of the Eyjafjallajökull ash

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On 14 April 2010, when meltwaters from the Eyjafjallajökull glacier mixed with hot magma, an explosive eruption sent unusually fine-grained ash into the jet stream. It quickly dispersed over Europe. Previous airplane encounters with ash had resulted in sand blasted windows and particles melted inside jet engines, causing them to fail. Therefore, air traffic was grounded for several days. Concerns also arose about health risks from fallout, because ash can transport toxic elements such as fluoride, aluminium and arsenic. For this study, we compared samples of the initial explosive ash with ash from the later, more typical eruption. Using nanotechniques, custom-designed for studying natural materials, we explored the physical and chemical nature of the ash to determine if fears about health and safety were justified and we developed a protocol that will serve for assessing risks during a future event [1].

We used atomic force spectroscopy (AFS) to map the adhesion properties on individual ash particles. With X-ray photoelectron spectroscopy (XPS), we determined the composition of nanometer scale salt coatings. By oscillating an atomic force microscopy cantilever, to which a single ash particle had been glued, we could measure the mass of adsorbed salts with picogram (pg; $10^{-12}$ g) resolution. The particles of explosive ash that reached Europe in the jet stream were especially sharp and hard, therefore abrasive, over their entire size range, from submillimeter to tens of nanometers. Edges remained sharp, even after 2 weeks of abrasion in stirred water suspensions. From the composition of the particles, we could predict that they would soften and melt at temperatures typical of a jet engine (1500 to 2000 °C).

This paper is the second of a two part presentation, where the first part, by Sigurdur Gislason, focuses on the Eyjafjallajökull eruption, grain size distribution and soluble salt coatings.

[1] Gislason S.R. *et al.* (2011) *PNAS*, **108**, 7307-7312

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# Biogeochemical cycling of cadmium in the Tasman Sea: Constraints from cadmium isotopes

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The biogeochemical cycling of cadmium (Cd) is likely to be an important component of the ocean's biological pump, yet the processes controlling its uptake are poorly understood. Stable isotopes of Cd offer the potential to provide new insights into the distribution and cycling of marine Cd, as sizeable 0.1%-level isotopic fractionation in seawater has been demonstrated due to biological uptake by marine phytoplankton [1, 2]. Furthermore, Cd isotopes may prove to be a reliable proxy for past and present nutrient utilization in the oceans. However, the limited results to date reveal the complex interplay of biological uptake, particle 'scavenging', and the mixing of different water masses. Additional datasets are, therefore, required to gain insight into the processes that govern the marine distribution of Cd.

Using multiple-collector inductively coupled plasma mass spectrometry (MC-ICPMS) combined with double spiking techniques, we report the Cd isotopic composition and concentration of depth profile samples collected along a longitudinal transect in the Tasman Sea during the SS01/2010 ('PINTS') voyage — a GEOTRACES Process Study. The sampling transect extended southwards from the sub-tropical Pacific Ocean to the Southern Ocean, characterised by a strong longitudinal gradient with respect to the supply of trace metal-bearing dust, phytoplankton biomass, and oceanic temperature. The Cd isotopic and concentration water column signatures are interpreted in the context of other trace metals and macronutrients that potentially colimit marine phytoplankton growth, as well as oceanographic parameters, such as phytoplankton biomass. These data help elucidate the sources and biogeochemical cycling of Cd in the Tasman Sea, the validity of the Cd/Ca paleonutrient proxy, and the potential of Cd isotopes as a proxy of past nutrient utilization in the oceans.

[1] Ripperger *et al.* (2007) *EPSL* **265**, 229–245.
[2] Abouchami *et al.* (2011) *EPSL*, in press.