Solid-gas interactions in the eruption plume can both depress and enhance volcanic ash ice-nucleating activity

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U N I V E R S I T Y  O F  L E E D S

Materials and Methods

Five silicate materials studied: Tungurahua tephra (TUN), Astroni tephra (AST), Etna tephra (ETN), K-feldspar (FELD), Smoky quartz (QRTZ)

Samples were exposed in an Advanced Gas-Ash Reactor at 800/400 °C to water vapour on its own (H2O) or mixed with SO2(g) (H2O-SO2) or HCl(g) (H2O-HCl) for 1200 seconds

Soluble compounds formed on samples were assessed by leaching in water, filtration and analysis by ICP-OES and IC

Ice-nucleating activity of samples was assessed by cold stage droplet assays using a microlitre Nucleation by Immersed Particles Instrument

Materials and Methods

Figure 1. Photo of the Advanced Gas-Ash Reactor showing the working tube within a three-stage furnace

Results Summary Figure

Figure 3. Difference in INA (ΔTf = 5 cm-2) between the H2O-treated, H2O-SO2-treated, or H2O-HCl-treated and the non-treated silicate materials. Values above or below the horizontal black line indicate that the INA of the treated samples is higher or lower, respectively, than the INA of the non-treated samples. The error bars reflect the ranges of values based on the standard deviations of mean Tf = 5 cm-2. Values for the treated and non-treated samples from replicate ice nucleation experiments.

H2O and H2O-HCl decreased INA relative to the non-treated material

H2O-SO2 either increased INA relative to the non-treated material (TUN and ETN) or decreased INA to a lesser extent (AST), to a greater extent (FELD), or to the same extent (QRTZ) as the other treatments

Differing effects of treatments likely reflect contrasting reactivities of the silicate materials towards H2O and SO2(g) or HCl(g)

Changes in tephra INA do not relate to a ‘solute effect’ of sulphate or chloride salts formed by reaction with SO2(g) or HCl(g) at high temperatures

Background

Volcanic ash can act as ice-nucleating particles, promoting freezing of supercooled water in the eruption plume and cloud and the atmosphere

It remains unclear what drives the large variation in ice-nucleating activity (INA) of ash reported in previous field and laboratory measurements

Our first study of a range of ash and glass samples suggests that crystalline phases (e.g., feldspar minerals) likely play an important role

However, ash surface properties can be modified by interactions with magmatic gases in the hot eruption plume and it is not known how such interactions might affect the INA of ash

References

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