

# Volcanic particle-ice interaction

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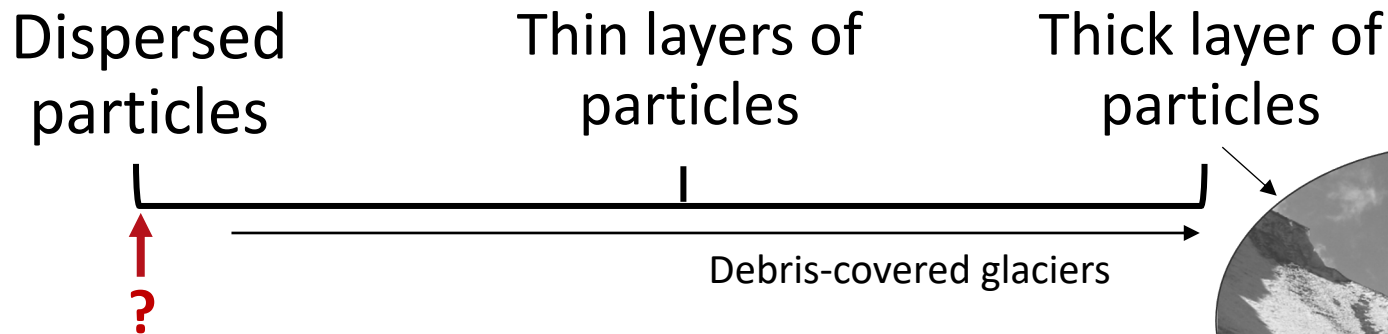
27.05.22, vEGU

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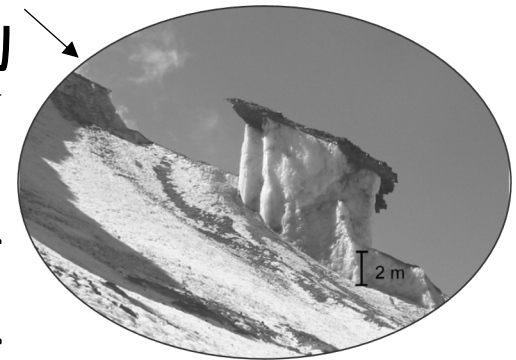
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# Importance of volcanic particle-ice interaction



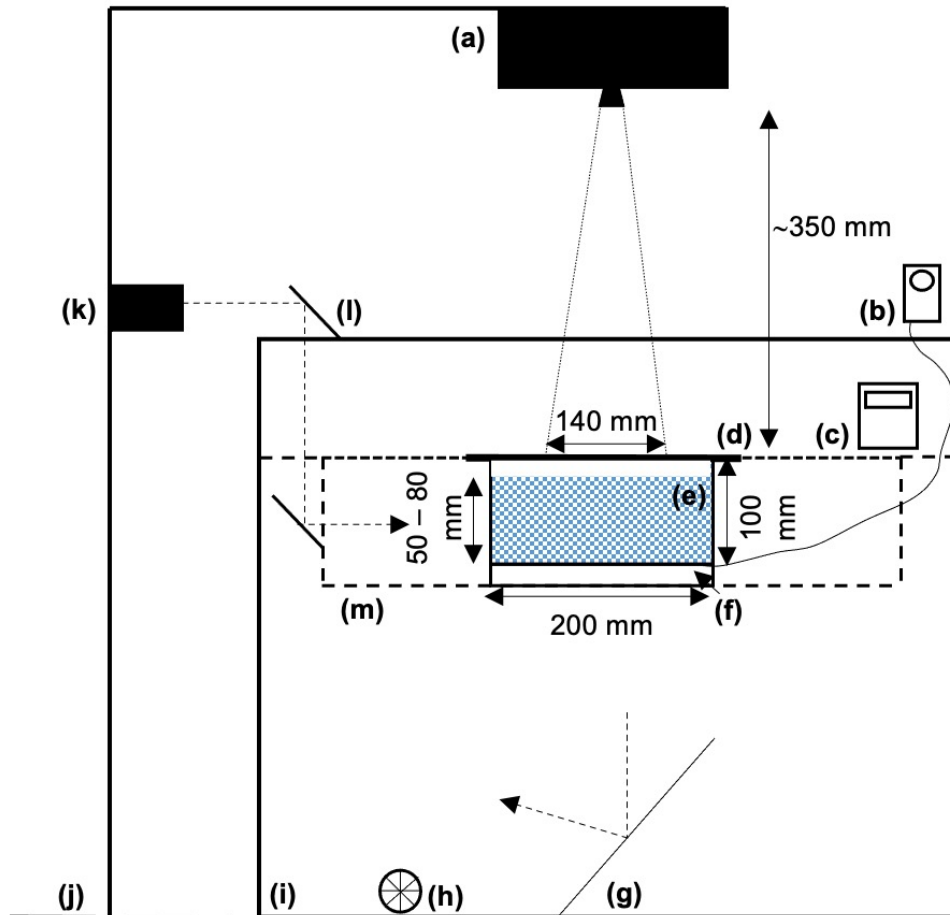
Important for prediction of future trends of ice loss and subsequent impacts (e.g. water supply, changes to ecosystems, etc.).



Julio-Miranda et al. (2008)

- Laboratory experiments investigated the behaviour of
- volcanic particles on an ice surface
  - volcanic particle movement once within an ice system.

# Methods



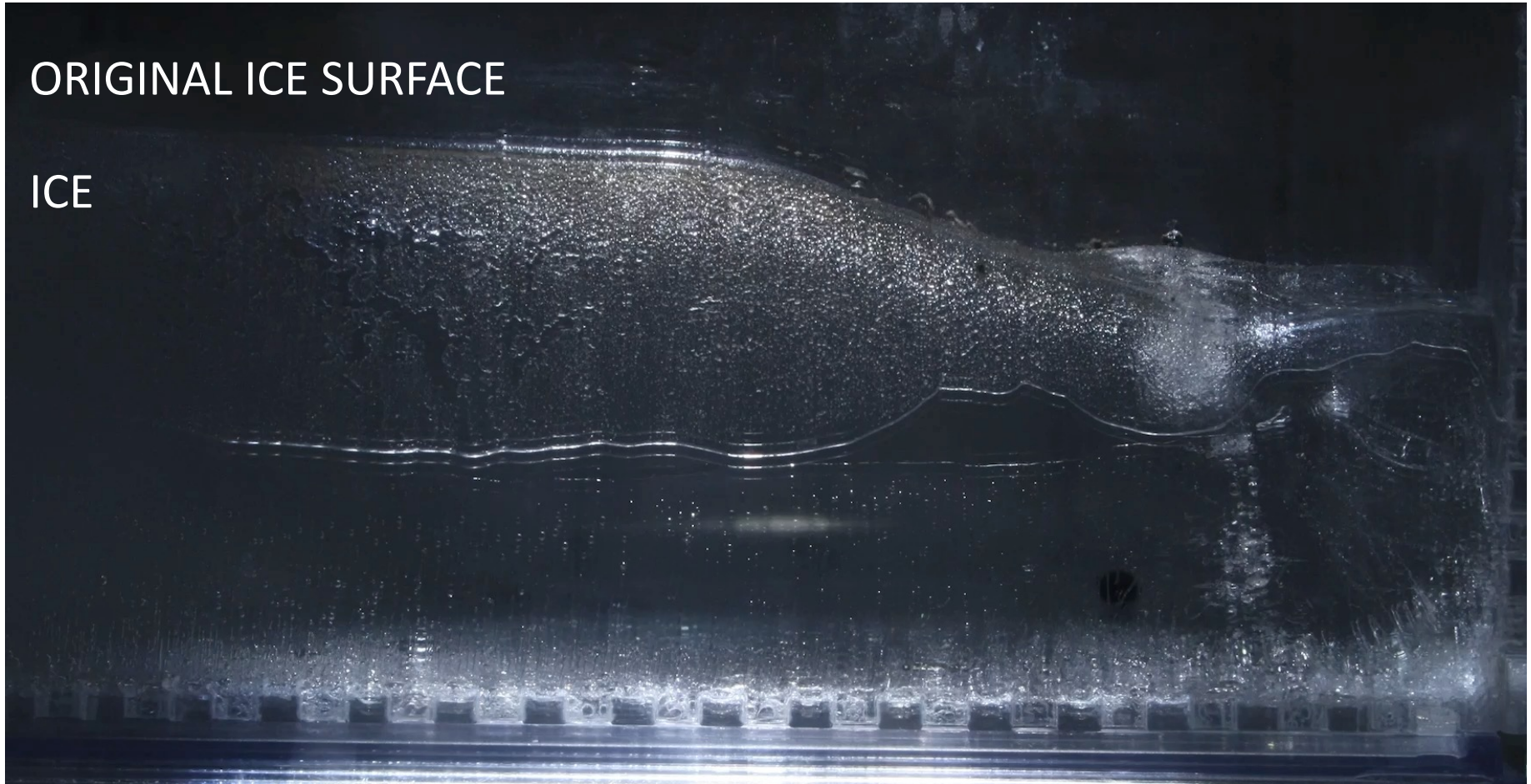
- (a) 80 W white LED bulb with projector as artificial radiation source
- (b) RS-1316 dual data logger thermometer with type 'K' thermocouple to monitor proxy-ice temperature
- (c) Thermo Pro humidity and temperature monitor to measure freezer temperatures
- (d) Glass cover to prevent sublimation
- (e) Clean ice block suspended approximately 0.5 m above freezer floor
- (f) Plastic stand for ice block
- (g) Angled mirror to prevent direct reflection off the freezer floor back onto the ice block
- (h) Fan to disrupt the thermal stratification of the freezer
- (i) Chest freezer
- (j) Stand
- (k) Canon (EOS D50D) camera taking time-lapse imagery (every 5 minutes)
- (l) Mirrors to act as a periscope system so that the cross-section of the ice block can be captured
- (m) Wire shelf

**Figure 1.** Diagram indicating the experimental set up, where 'LED' is light-emitting diode, and 'W' is Watts.

E.g. a scattering of basaltic-  
andesitic scoria particles (< 3 mm)

ORIGINAL ICE SURFACE

ICE



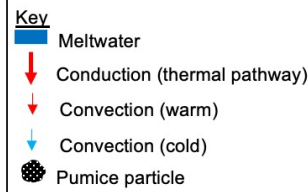


The low thermal conductivity of the pumice particle resulted in the top surface warming up. This encouraged strong convective heat losses to the atmosphere.

(1)

A high pumice particle porosity facilitated immediate percolation of meltwater into the previously air-filled pore spaces by capillary action. This hypothesis was supported by results from experimental and field work conducted by Hobbs (2014) and Juen et al. (2013), respectively.

Conduction of heat through the particle, and heating from convection in the atmosphere, resulted in particle-induced ice melt.



(2)

The base of the particle was in direct physical contact with the underlying ice, facilitating thermal conduction of heat through the ice away from the particle base.

Conduction of heat away from the ice resulted in freezing of meltwater at the particle base at the point of contact. Water expanded during refreezing processes, placing stress on the particle base and causing fracturing.

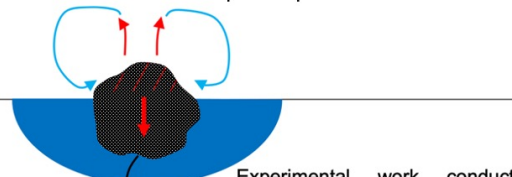
(3)



Fracturing from freeze-thaw action at the particle base produced a smaller (< 3 mm) fragment of pumice.

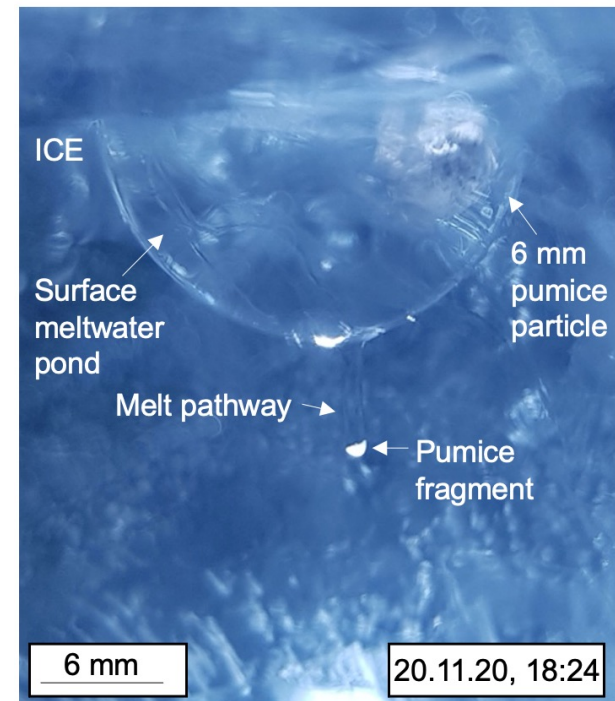
Melting of the frozen meltwater within the pumice allowed the pumice fragment to drop from the base of the particle once sufficient meltwater was produced for the pumice particle to float.

(4)



The pumice fragment moved downwards following a saturation of the fragment leading to an associated increase in particle density.

Experimental work conducted by Whitham and Sparks (1986) indicated that smaller pumices absorb water efficiently. This explains the difference in behaviour between the larger, floating pumice, and the smaller, sinking pumice fragment.



# Conclusions

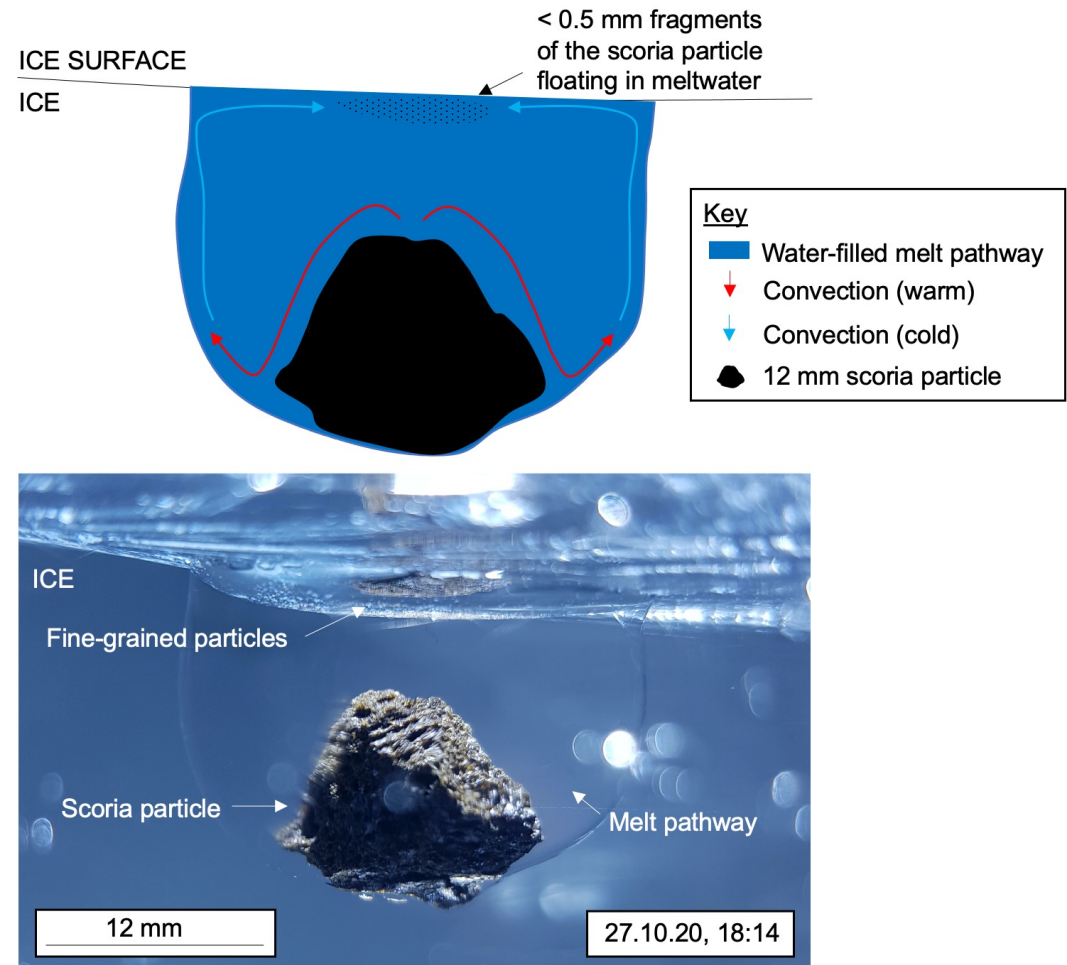
- Strong convection systems associated with embedded volcanic particles with a low thermal conductivity
- Multiple focal points of melting
- Fragmentation of particles is common
- A single volcanic particle is rarely a 'single' particle
- Volcanic material can effectively melt an ice system



Thank you for attending, any questions?

# Results: (1) melt pathway

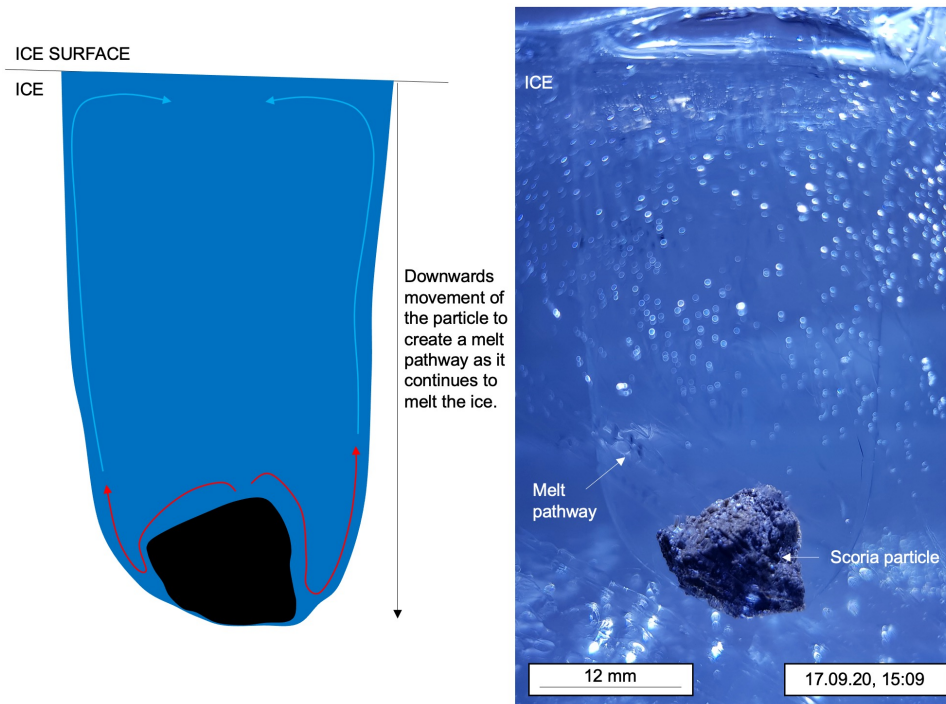
- A particle absorbs incoming radiation and transfers heat into the ice to cause ice melt. A high density particle moves downwards in meltwater to create a 'melt pathway' (Fig. 2).



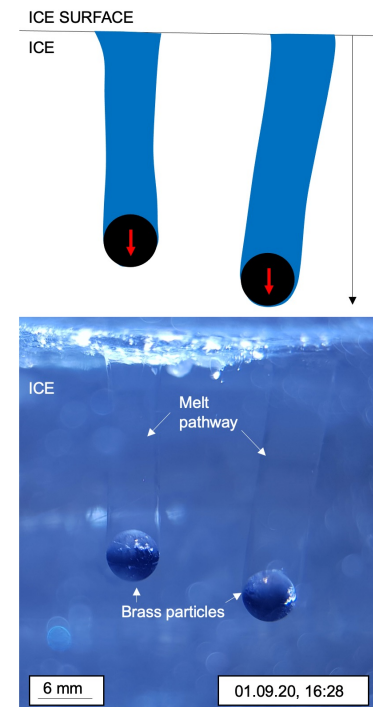
**Figure 2.** Line drawing and photograph of 12 mm scoria particle moving downwards into the ice and associated melt pathway.

# Results: (1) melt pathway

(a) Wide melt pathway associated with low thermal conductivity.









(b) Narrow melt pathway associated with high thermal conductivity.



**Figure 3.** Line drawing and photograph of (a) a 12 mm scoria particle and (b) a 6 mm brass particle and the associated melt pathways.

## Key

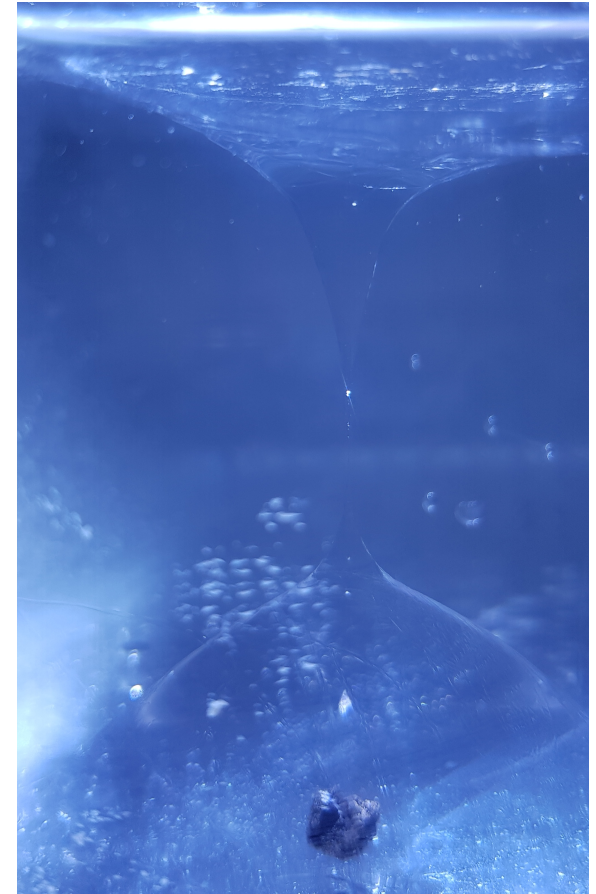
	Water-filled melt pathway		Convection (cold)
	Conduction (thermal pathway)		12 mm scoria particle
	Convection (warm)		6 mm brass particle



## Results: (2) a multiple particle system

- Downwards moving particle creates a melt pathway and basal meltwater pond – **embedded particles moving through ice system.**
- Fine-grained (e.g.  $<0.5$  mm) volcanic particles shed from the 'large' particle to float in meltwater and create a surface meltwater pond – **surface particles, melting  $\rightarrow$  runoff.**

= large volume of melt, despite refreezing conditions

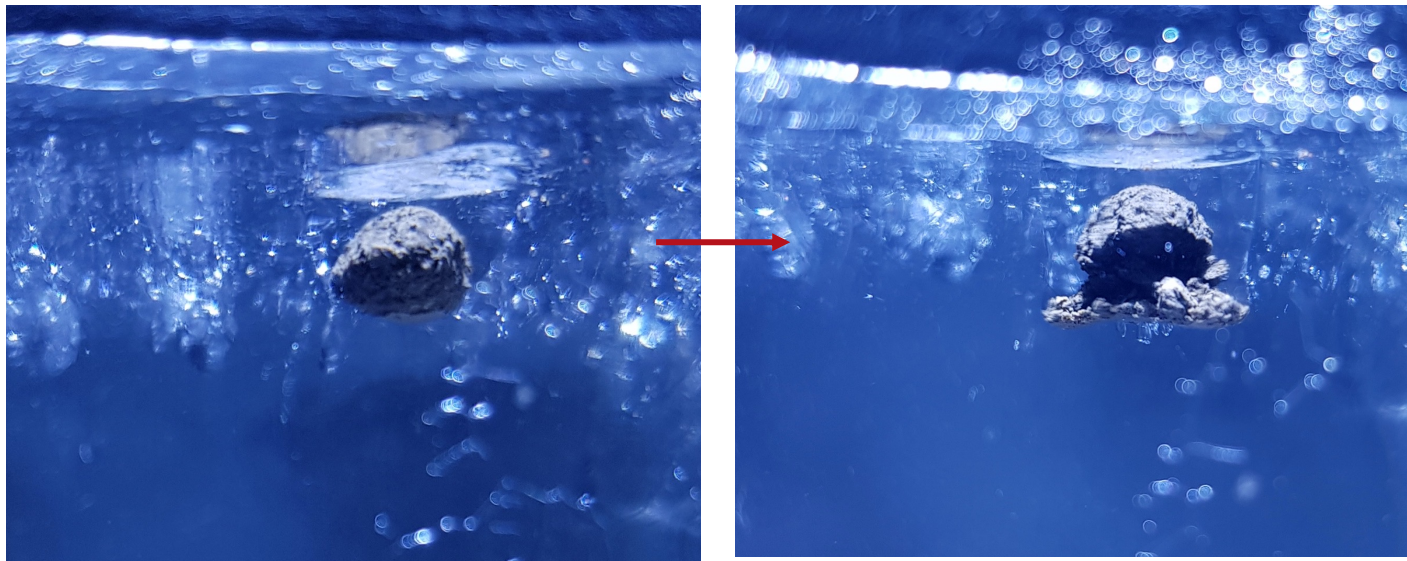


**Figure 5.** Photograph of 6 mm scoria particle and fine-grained material. Refreezing of melt pathway is noted. <sup>9</sup>



## Results: (3) particle fragmentation

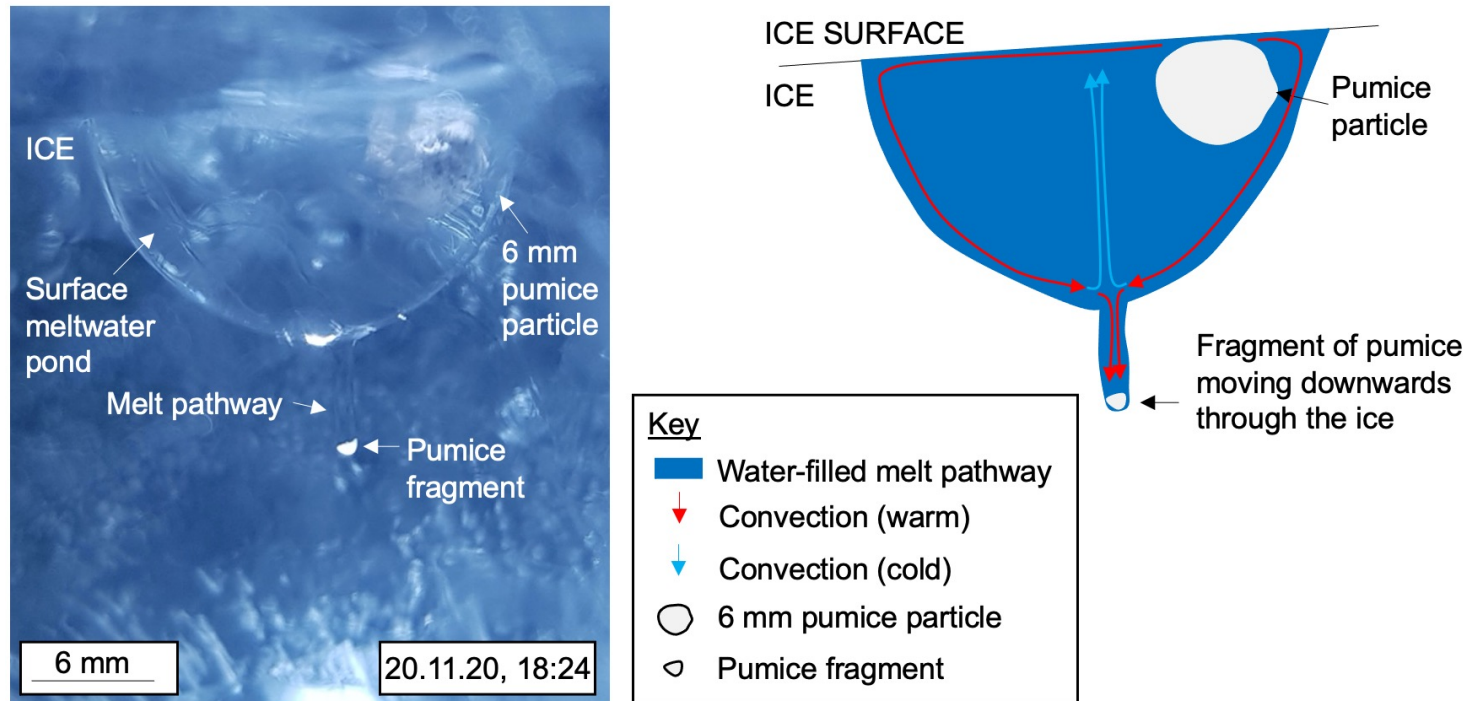
- Observed with cemented ash clusters from Eyjafjallajökull, Iceland (Fig. 6).



**Figure 6.** Photographs of disintegration of a 6 mm cemented ash cluster, where (a) is prior to disintegration and (b) is during disintegration.

# Results: (3) particle fragmentation

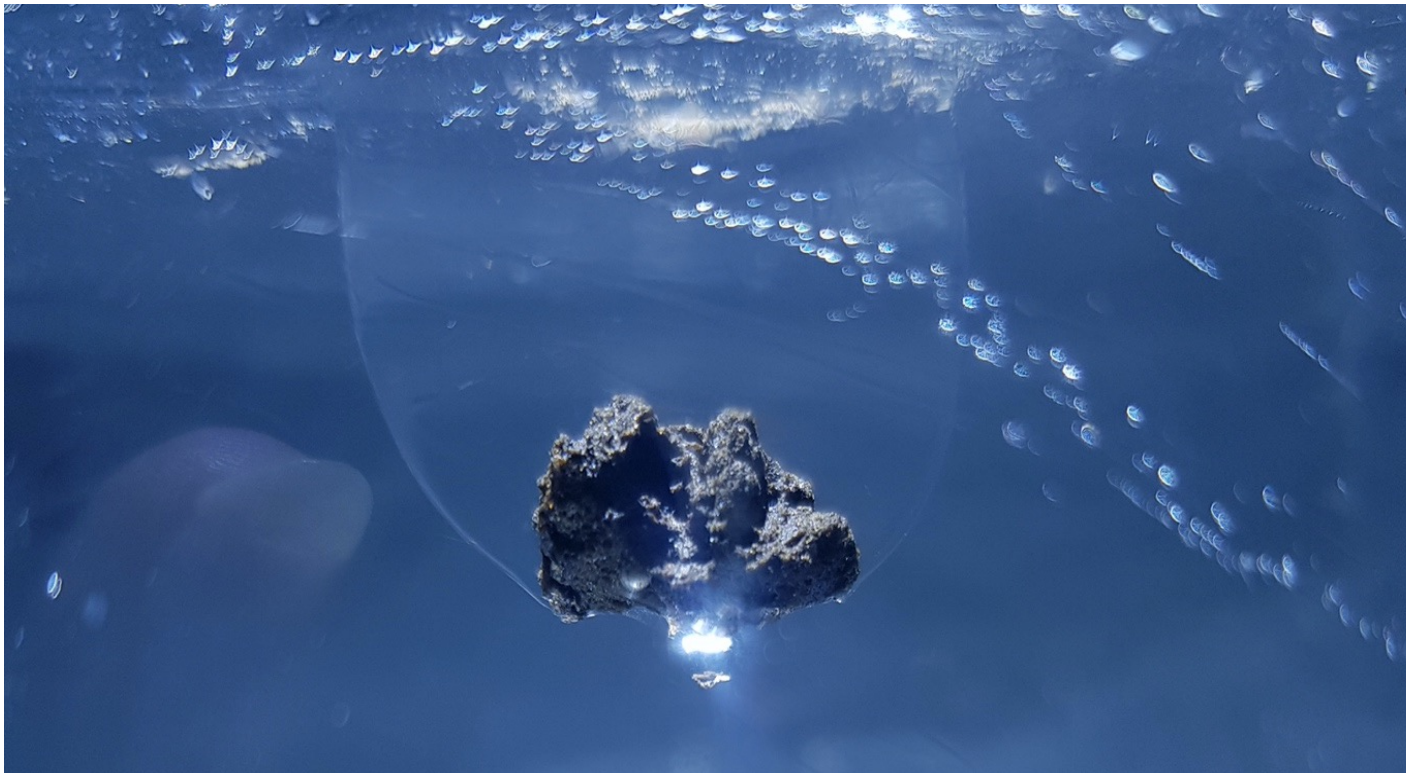
- Observed with pumice from Mt. St. Helens, USA (Fig. 7).



**Figure 7.** Photograph and line drawing of the fragmentation of a 6 mm pumice particle floating in a surface meltwater pond.

## Results: (3) particle fragmentation

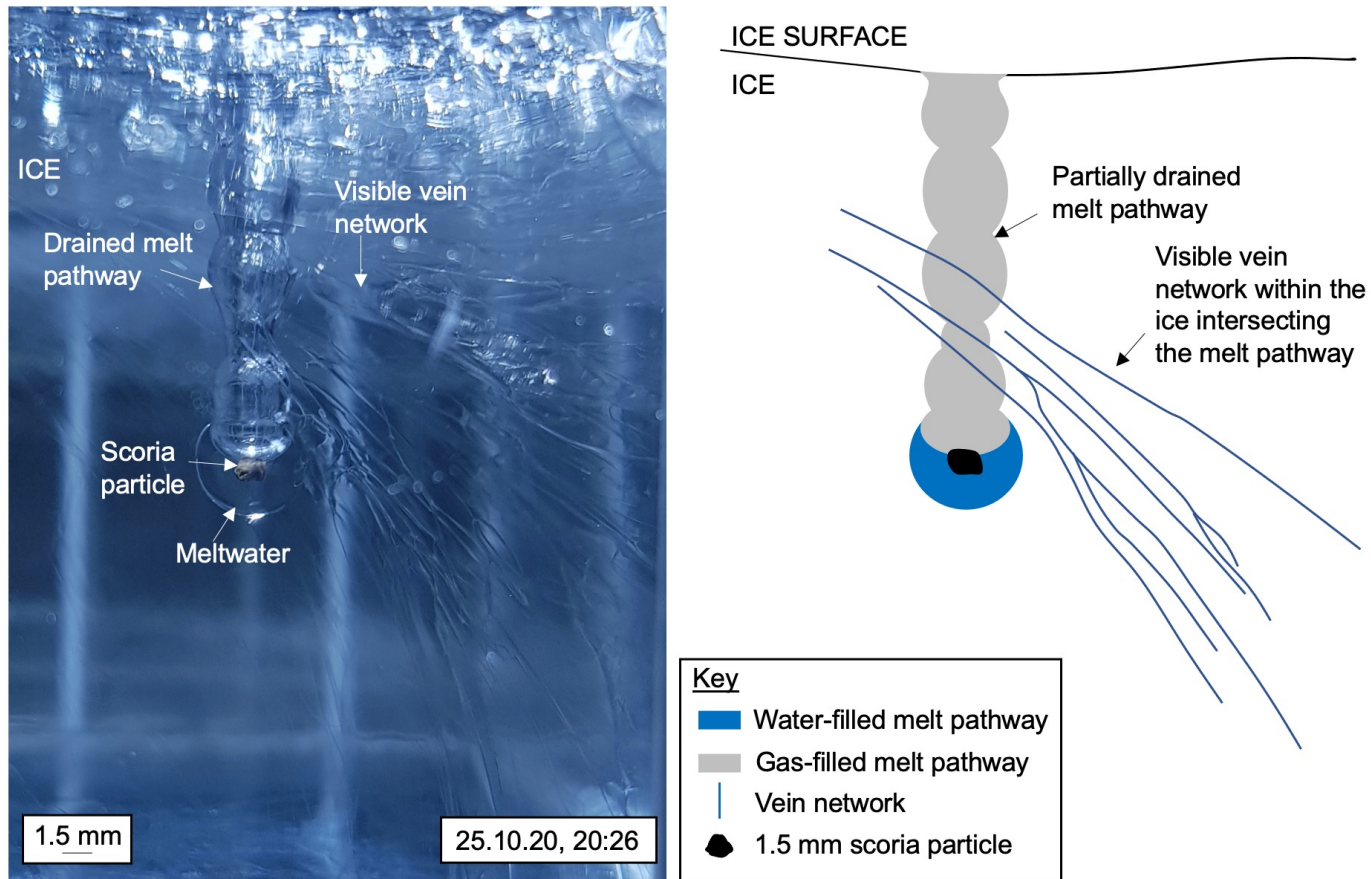
- Observed with scoria from Sollipulli, Chile (Fig. 8).



**Figure 8.** Photograph of fragmentation of a 12 mm scoria particle.



# Results: (4) particle interception with ice vein network



**Figure 4.** Photograph and line drawing of a 1.5 mm scoria particle within a drained melt pathway.