Volcanic ash

Just another solid matter in the atmosphere?

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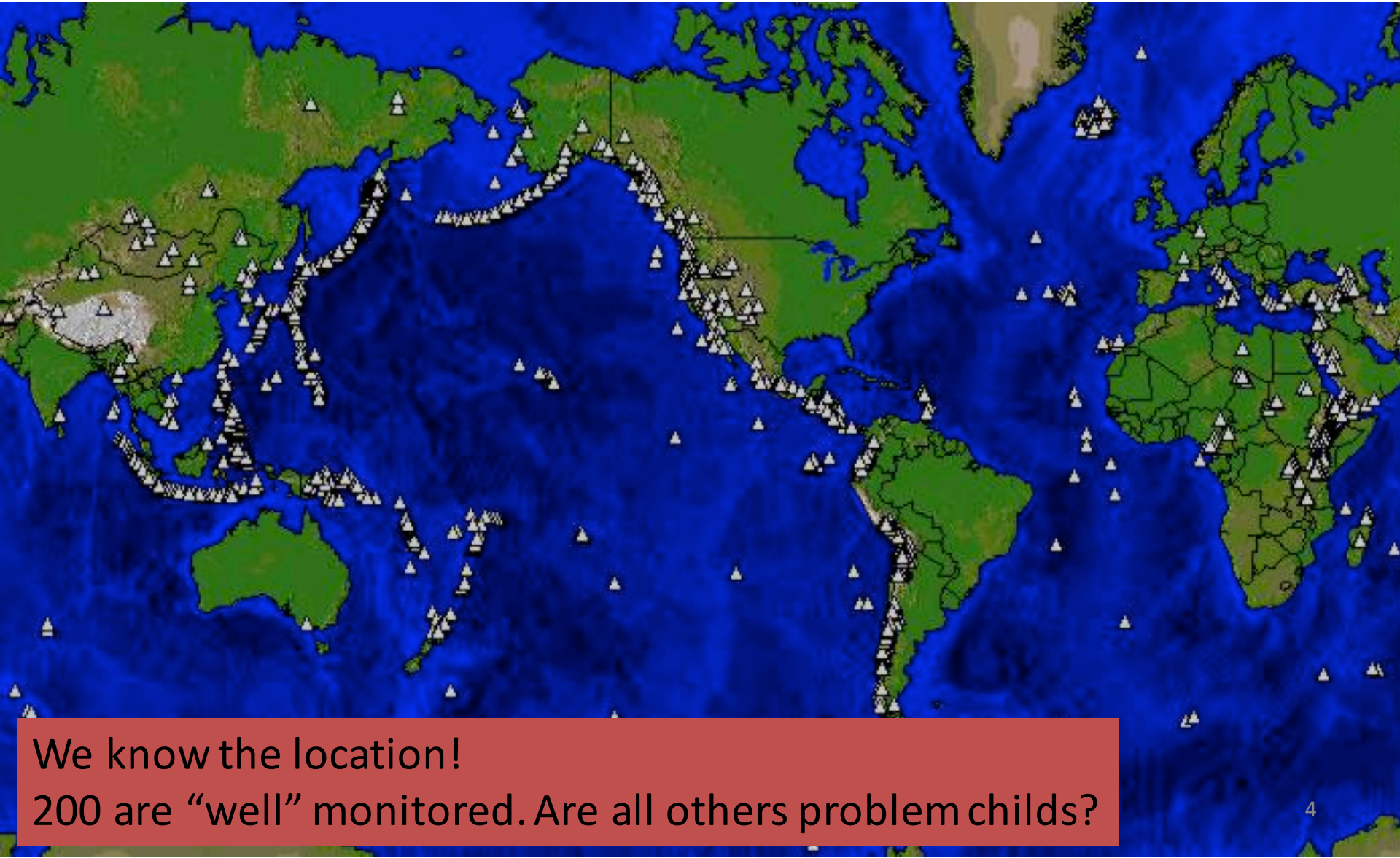
The volcano problem

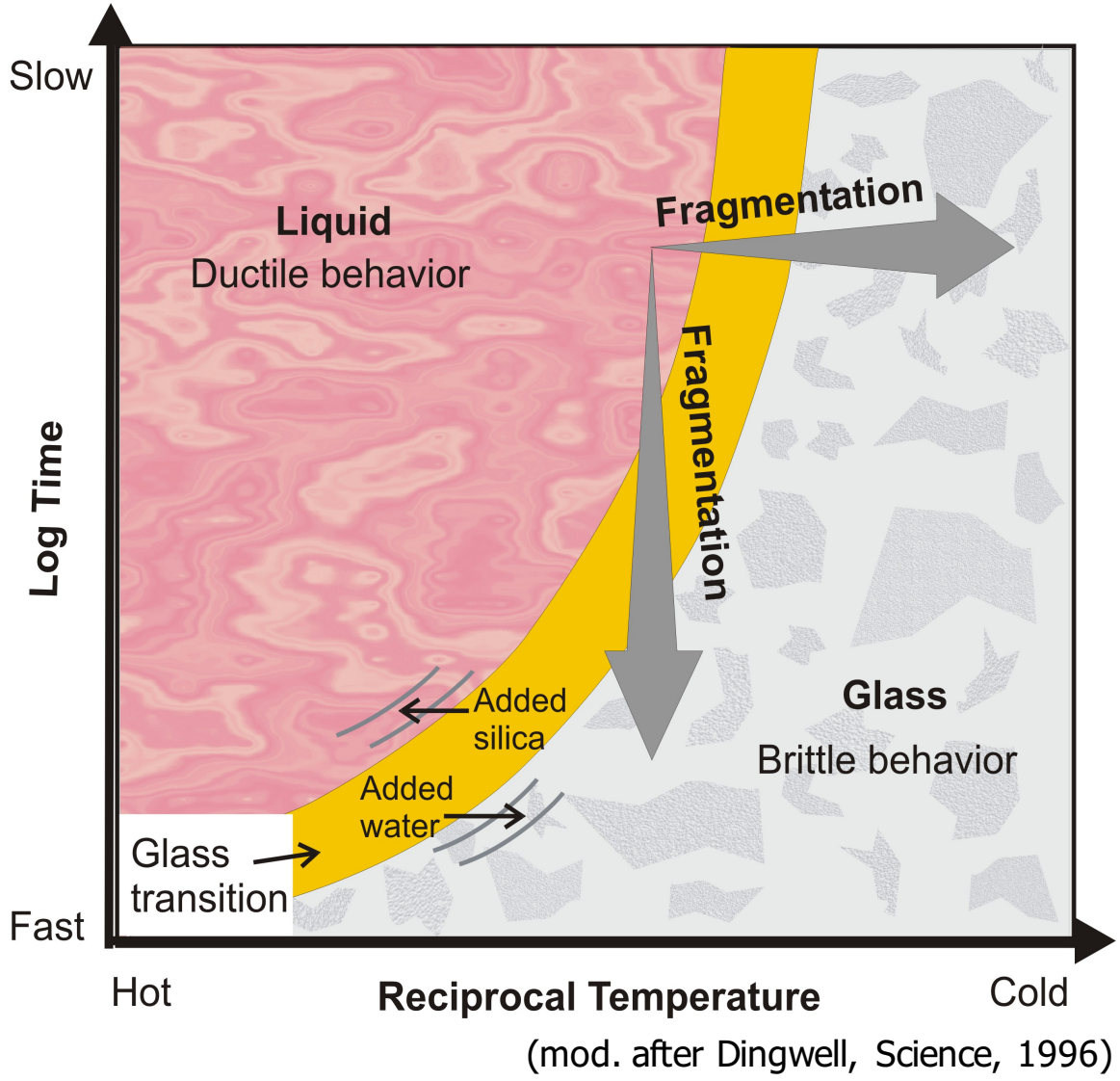
- Limited constraints on eruption onset, duration and recurrence frequency
- Volcanoes are individuals, no clones
- Variable ash production rate without single trend
- Variable eruption intensity
- Variable weather conditions

Active volcanoes (> 500)



We know the location!
200 are “well” monitored. Are all others problem childs?

Material failure – why and when?



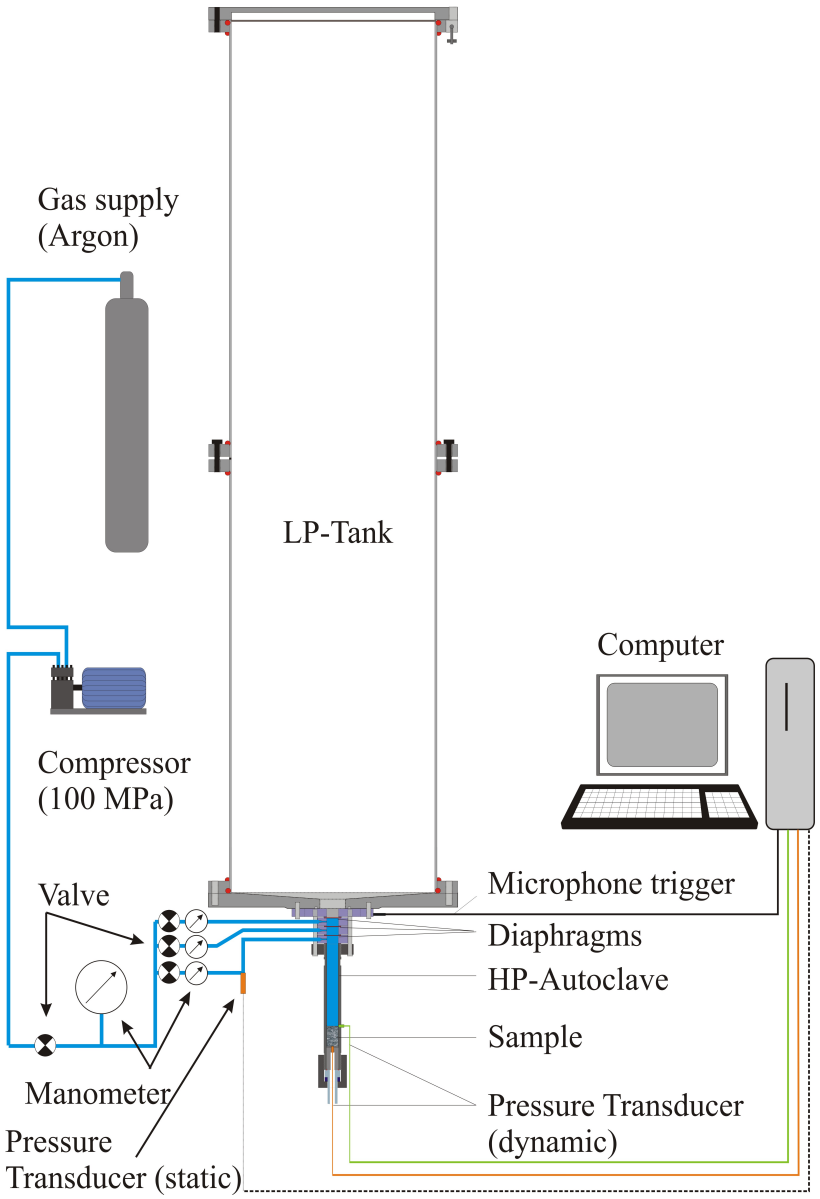
1. Lightning

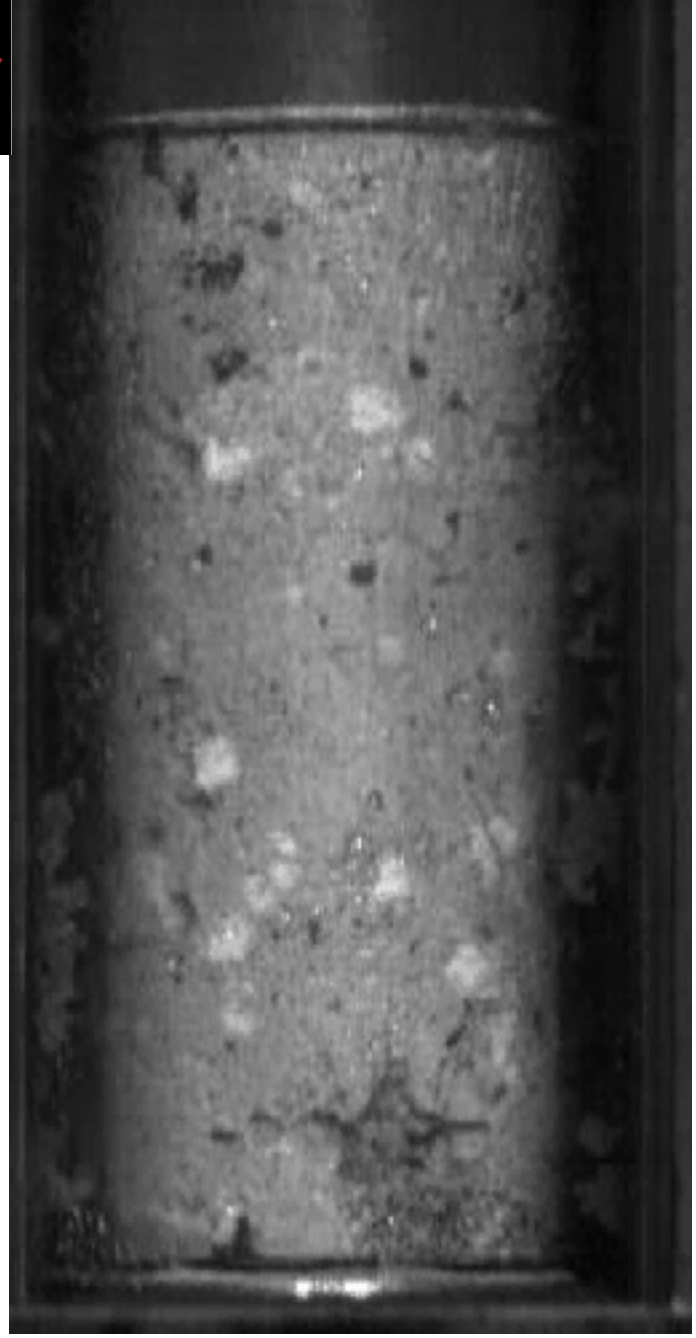
Sakurajima volcano,
July 2015

Courtesy:
Corrado Cimarelli

Filmed at 10 kfps

Munich “fragmentation bomb”





Magma fragmentation

Unzen

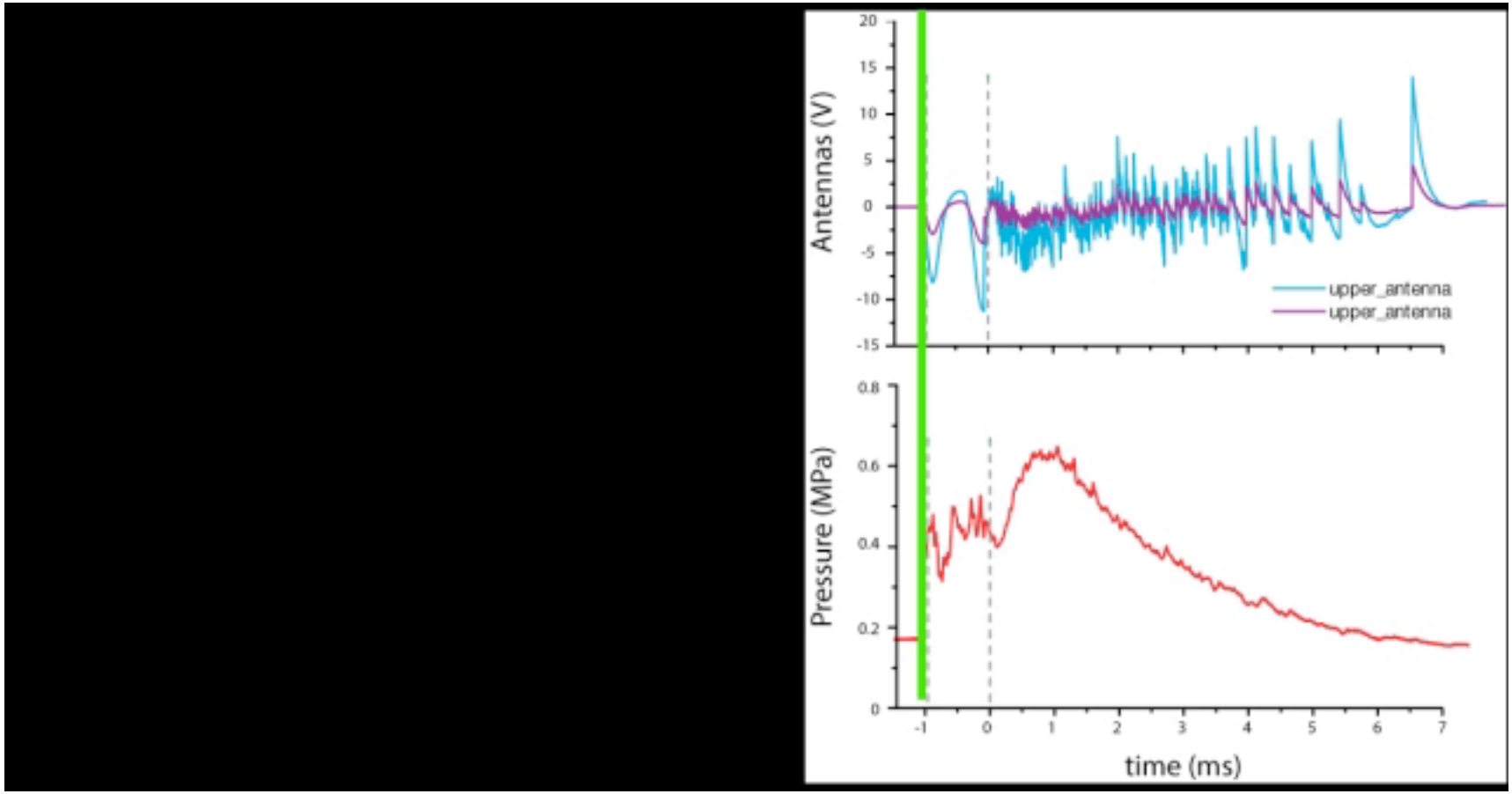
Φ = 48%

ΔP = 6MPa

Room T

Plexiglas autoclave

Laboratory lightning



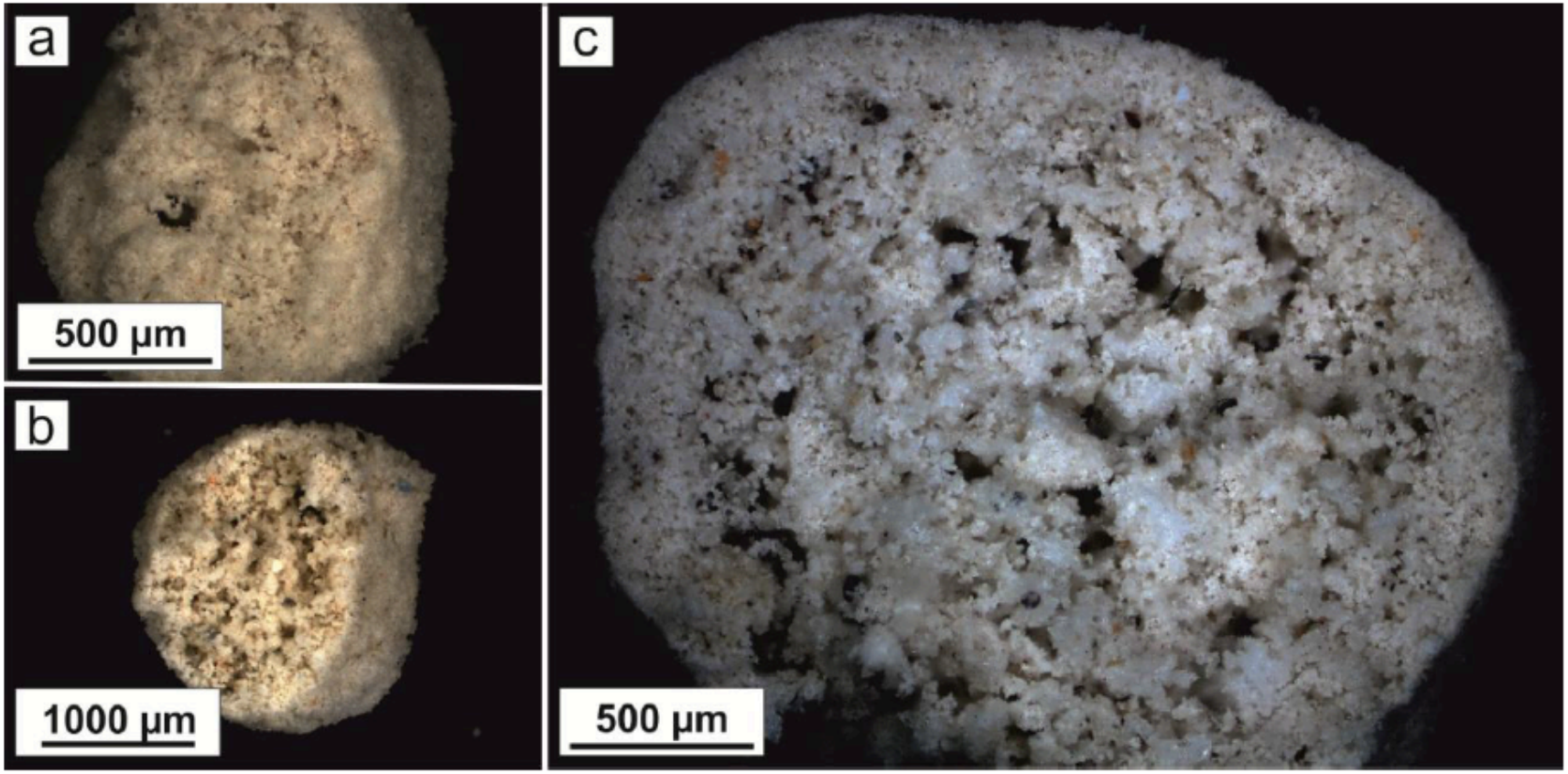
Cimarelli et al., Geology 2014

2. The source term problem

Weinzierl et al., 2012
Phys. Chem. Earth

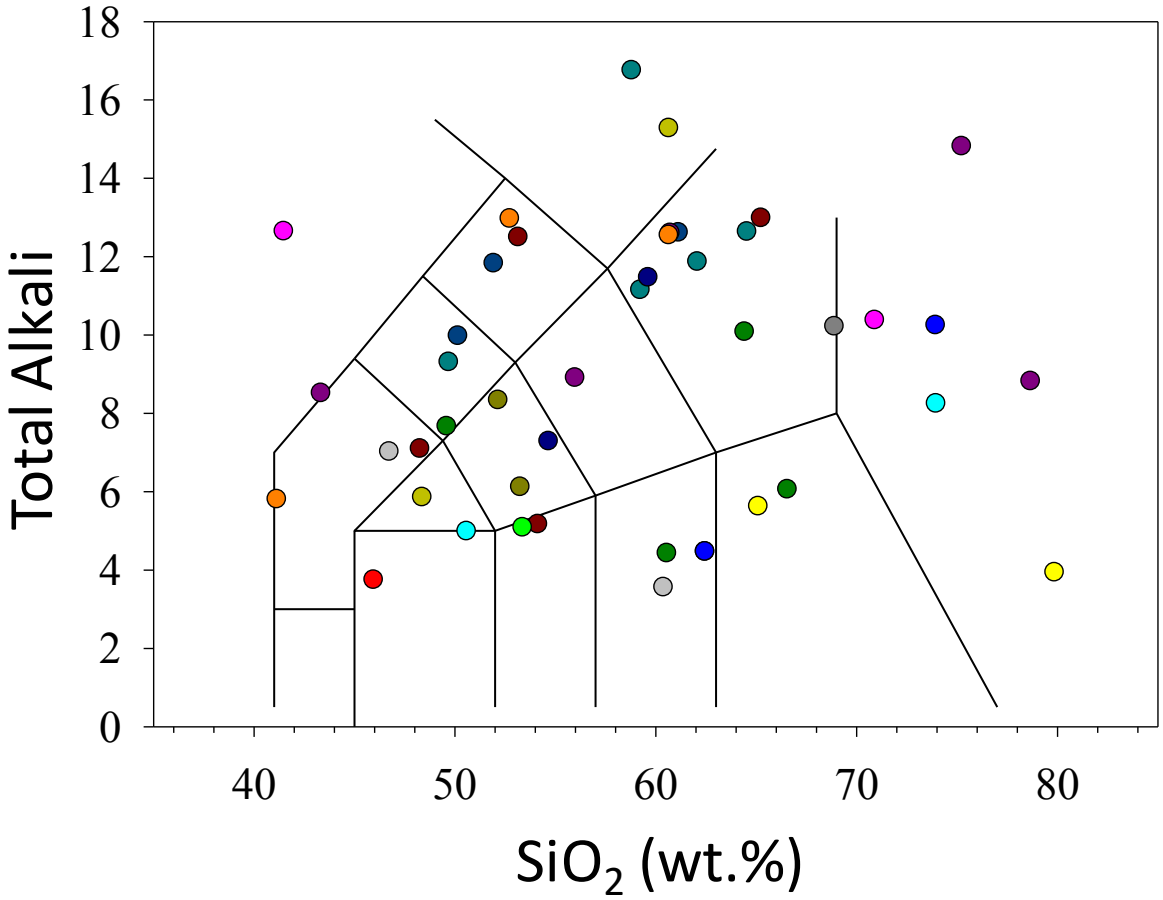
3. Ash aggregation (natural)

3. Ash aggregation (experimental)



Mueller et al., in press at EPSL

4. Ash properties



Chemical variability

Giordano et al., 2006
Bulk rock compositions

Significance of geochemical data

Table 1 Representative EPMA and XRD results of the EYJA, ATD and MIL samples used in this study

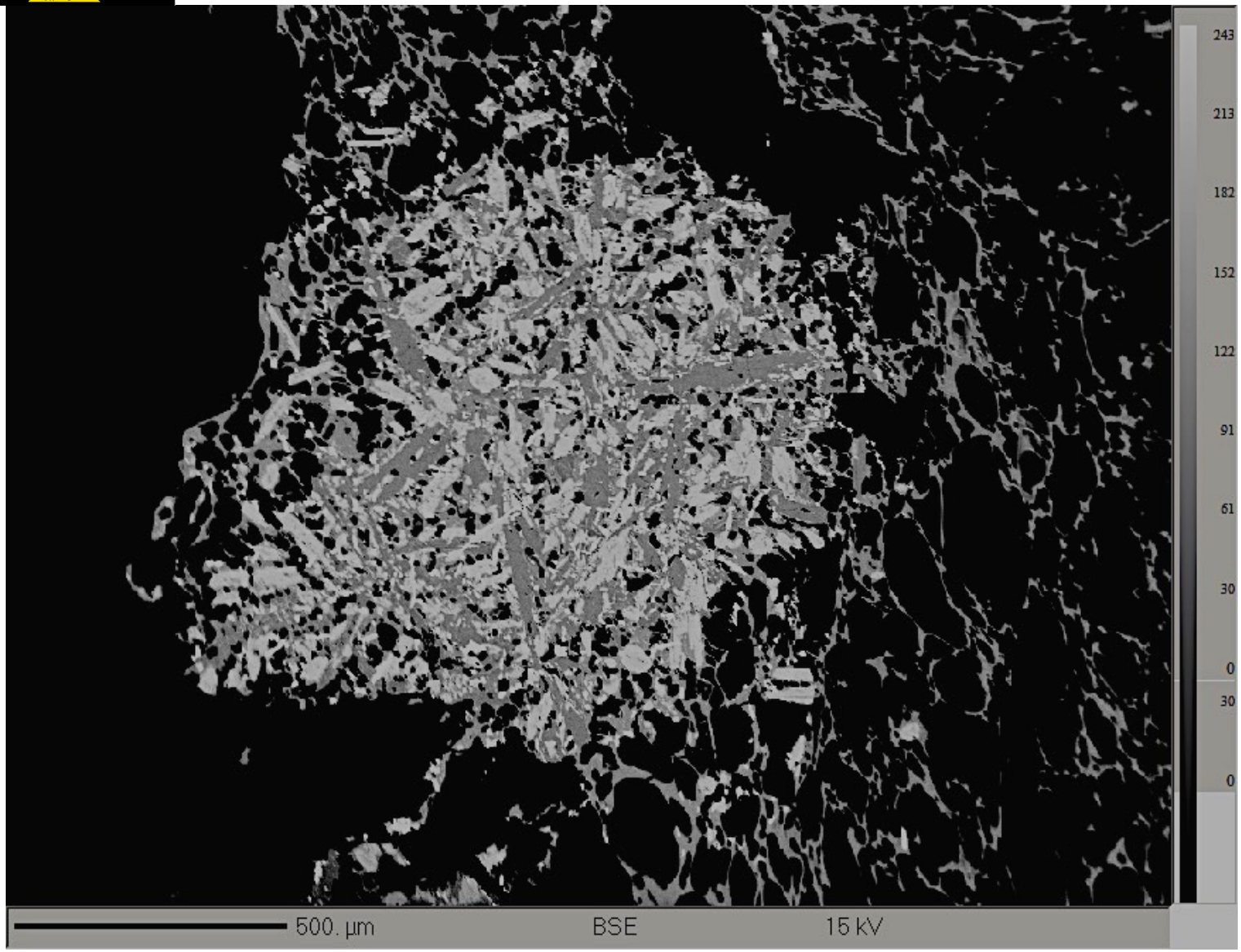
	EPMA point analysis					XRD bulk rock composition			
	A	C	D	E	F	A	C	E	F
	EYJA	MIL	MIL	ATD	ATD	EYJA	MIL	ATD	ATD
	φ < 63 µm	φ < 63 µm	90 < φ < 125 µm	90 < φ < 125 µm	φ < 63 µm	φ < 63 µm	φ < 63 µm	90 < φ < 125 µm	φ < 63 µm
SiO_2	66.38	100.48	100.35	100.13	100.14	60.72	95.92	88.34	74.02
Al_2O_3	15.62	0.03	0.06	0.02	0.02	14.82	2.97	5.67	10.79
FeO	4.81	0.01	0.03	0.02	0.07	8.99	0.46	0.92	2.97
MnO	0.16				0.00	0.21	0.00	0.03	0.09
MgO	0.62				0.00	2.51	0.15	0.47	1.33
CaO	2.78				0.02	4.58	0.04	1.25	2.49
Na_2O	5.26				0.01	5.81	0.22	1.03	1.32
K_2O	2.61				0.00	2.27	1.59	1.78	2.65
TiO_2	0.70	0.01	0.00	0.00	0.00	1.39	0.13	0.12	0.38
P_2O_5	0.18	0.00	0.00	0.00	0.01	0.25	0.03	0.05	0.13
Cl	0.22	0.00	0.00	0.01	0.00		Not analysed		
Total	**99.34**	**100.58**	**100.47**	**100.22**	**100.27**	**101.55**	**101.51**	**99.66**	**96.17**

Sample labeling, measured values and cumulative results in bold for clarification.

SiO_2 ≠ Quarz!

Kueppers et al., 2014, J Appl. Volc.

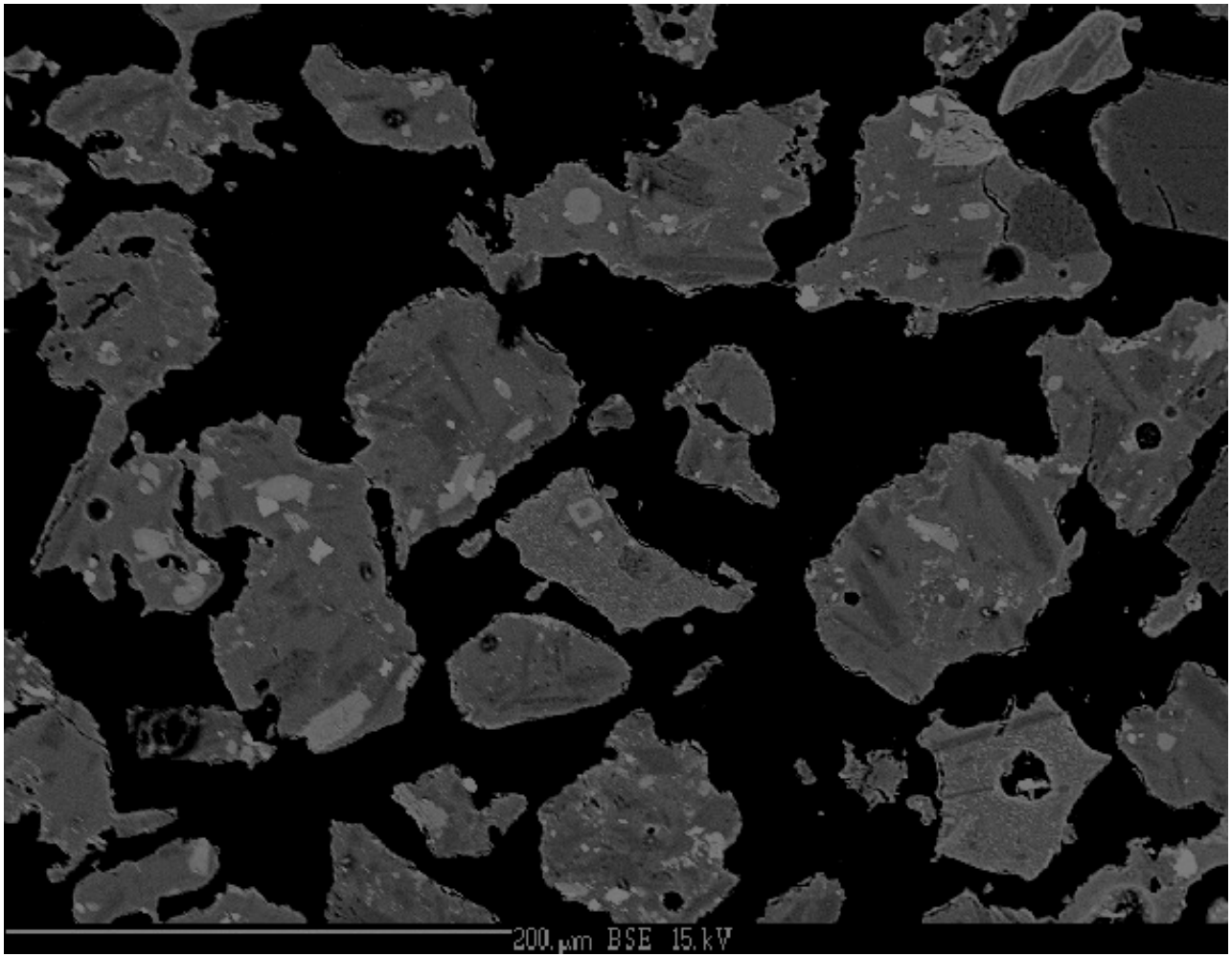
Magma textures



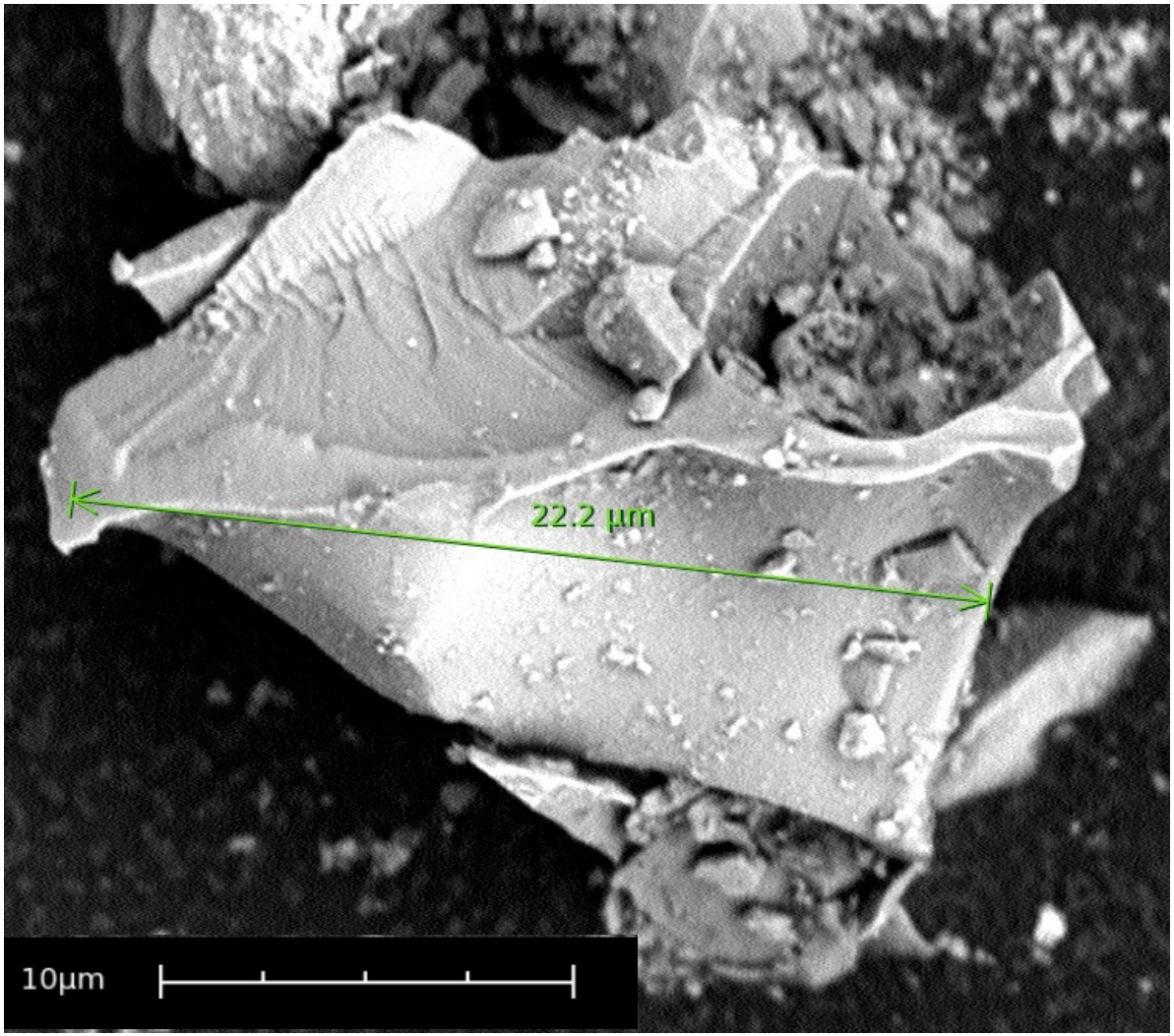
BSE image of ash From Sete Cidades volcano, Azores (PT)

Volcanic ash is a multiphase mixture

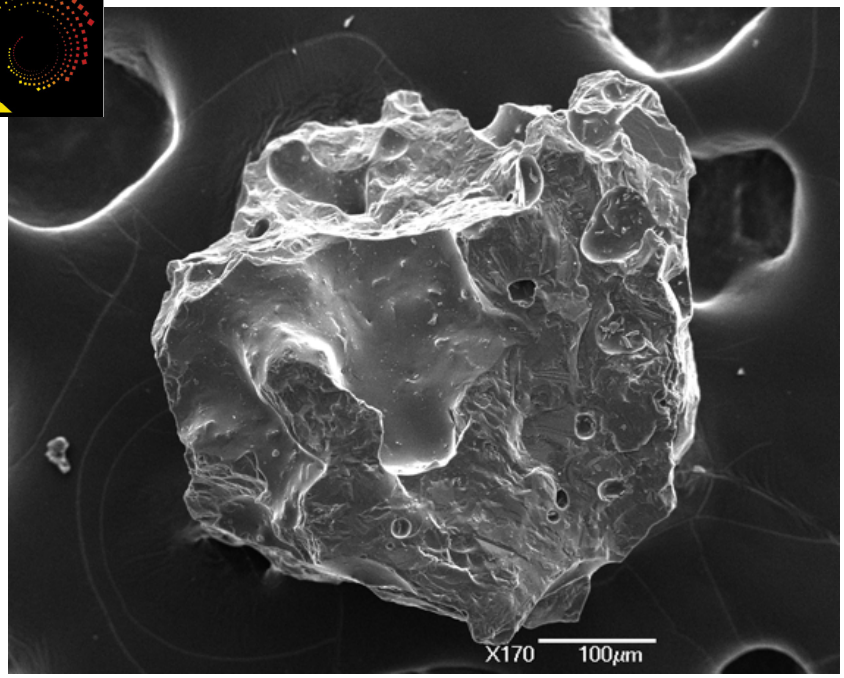
- Glass
- Crystals
- Bubbles

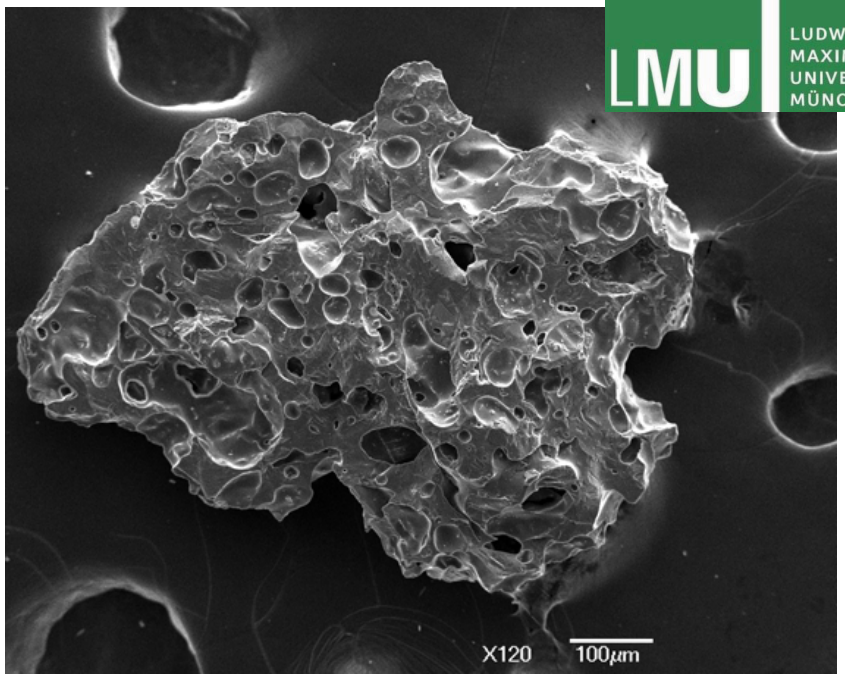


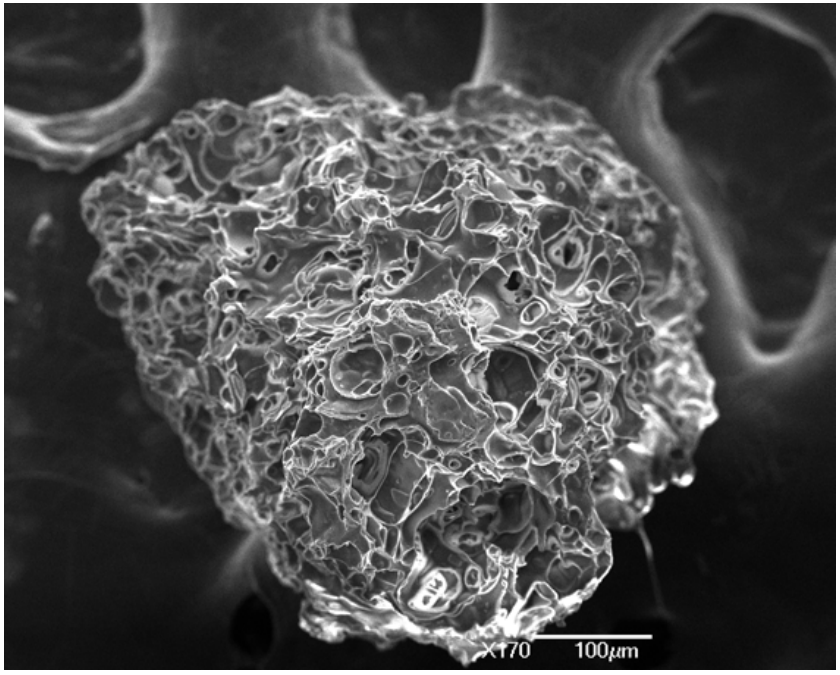
That's how ash looks like

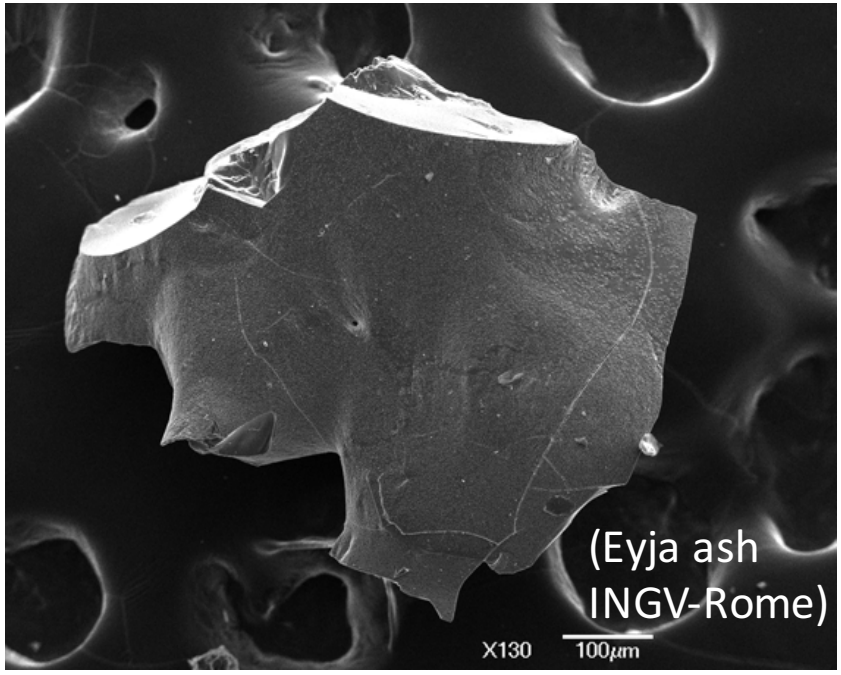


Eyjafjallajökull ash
of 18 May 2010

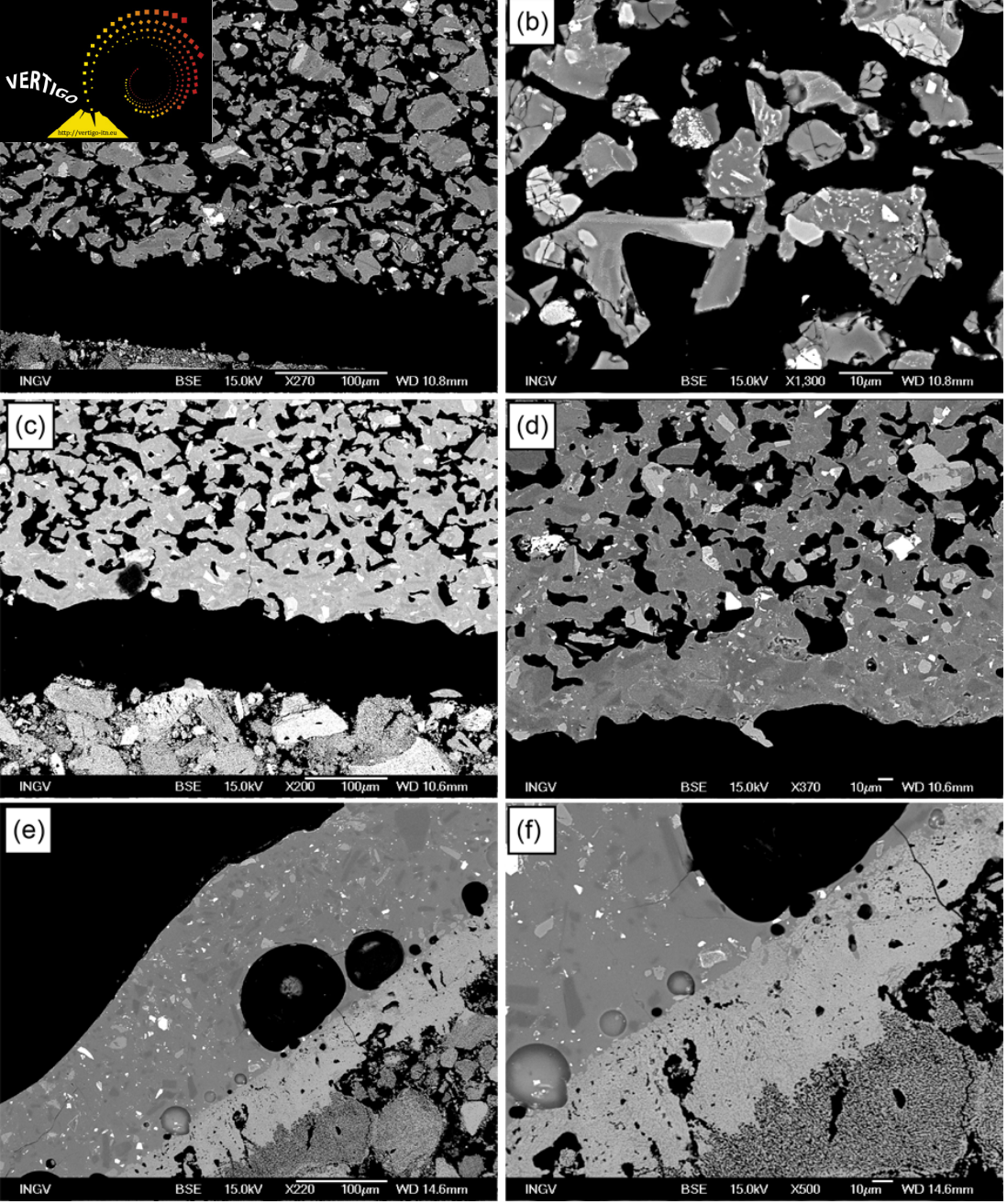








(Eyja ash
INGV-Rome)



950 °C, neck formation

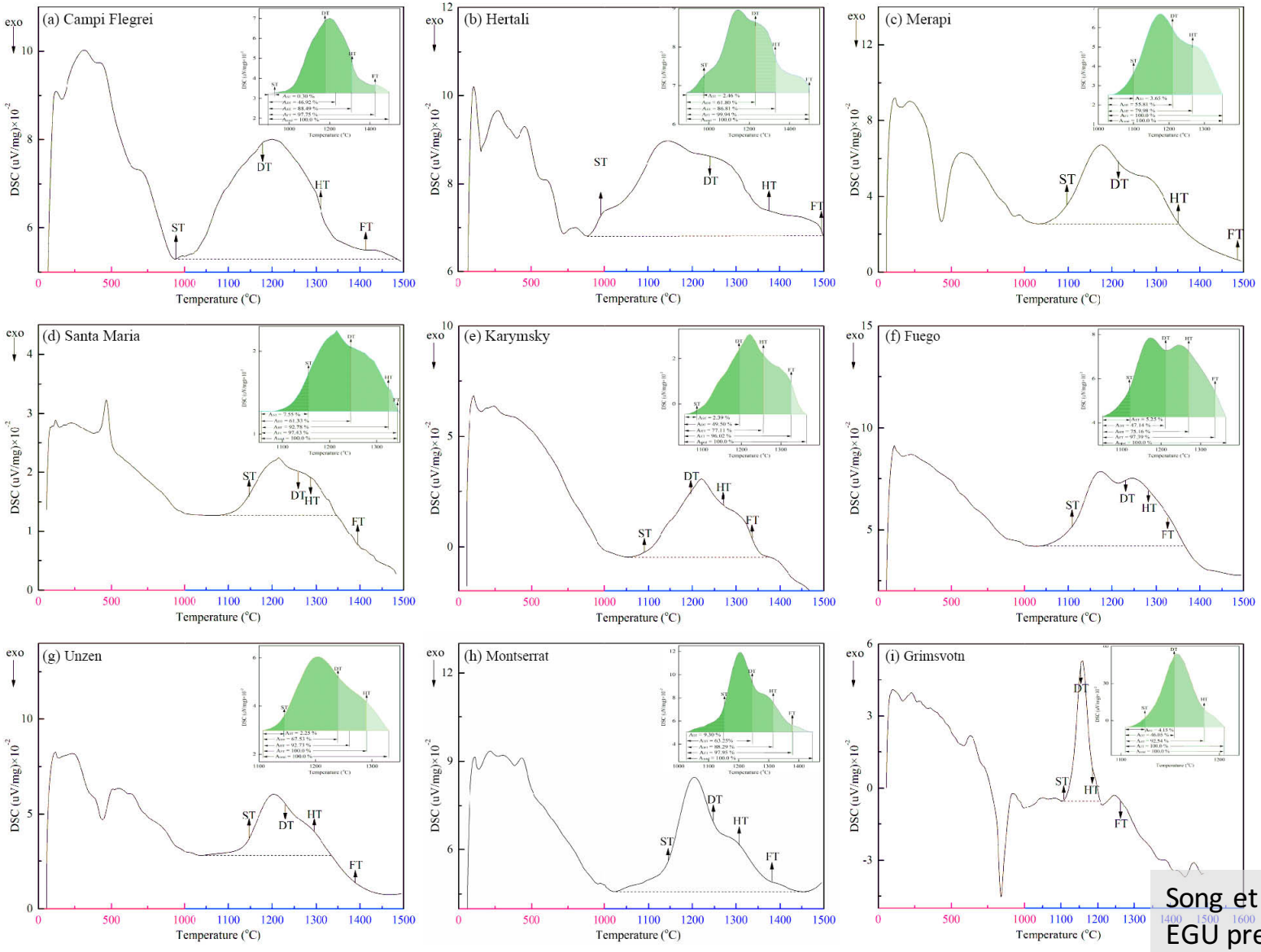
1000 °C, viscous flow

1050 °C, substrate infiltration

Eyja ash sintering, 60 min, < 63 µm

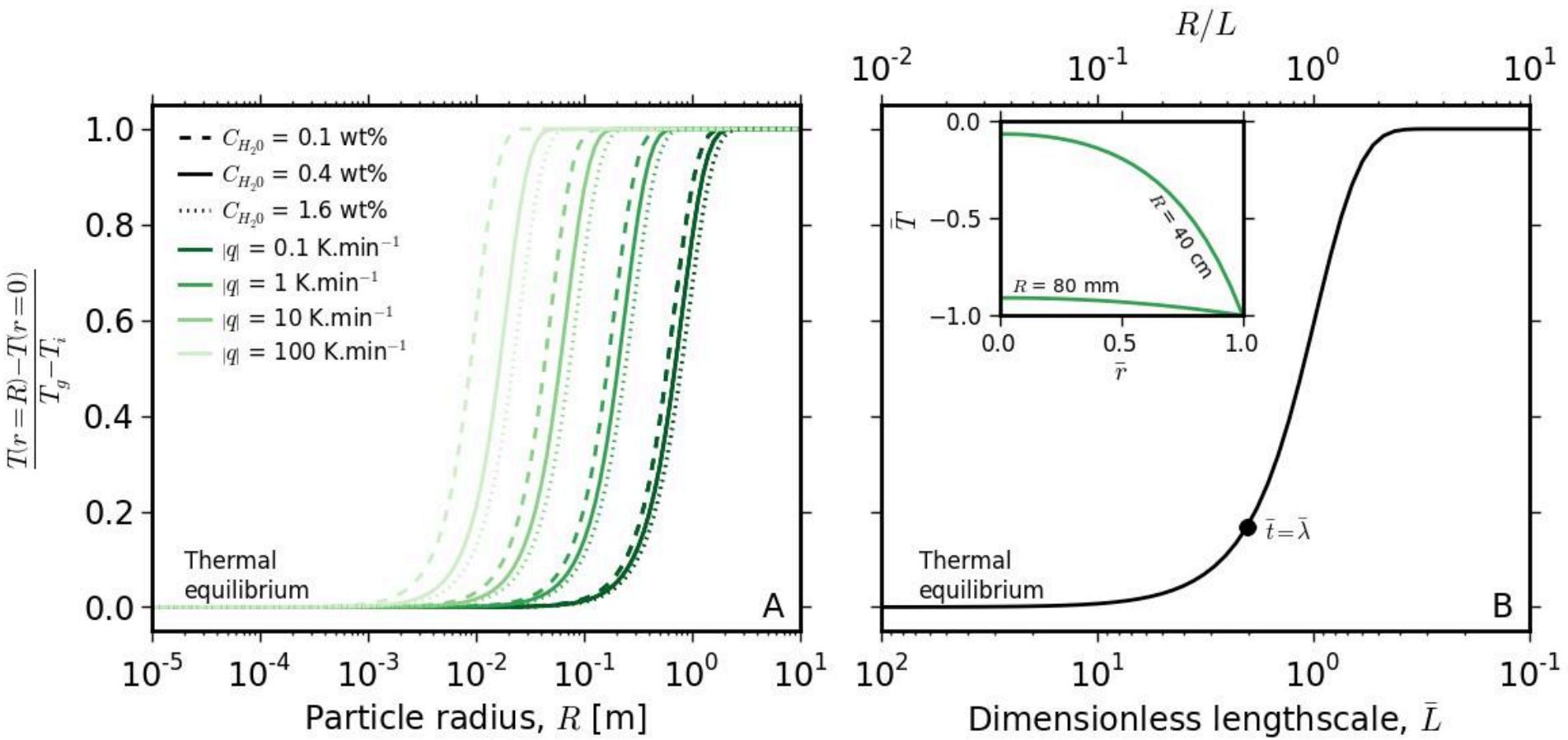
Kueppers et al., 2014
J Applied Volcanology

Thermal analysis (DSC)



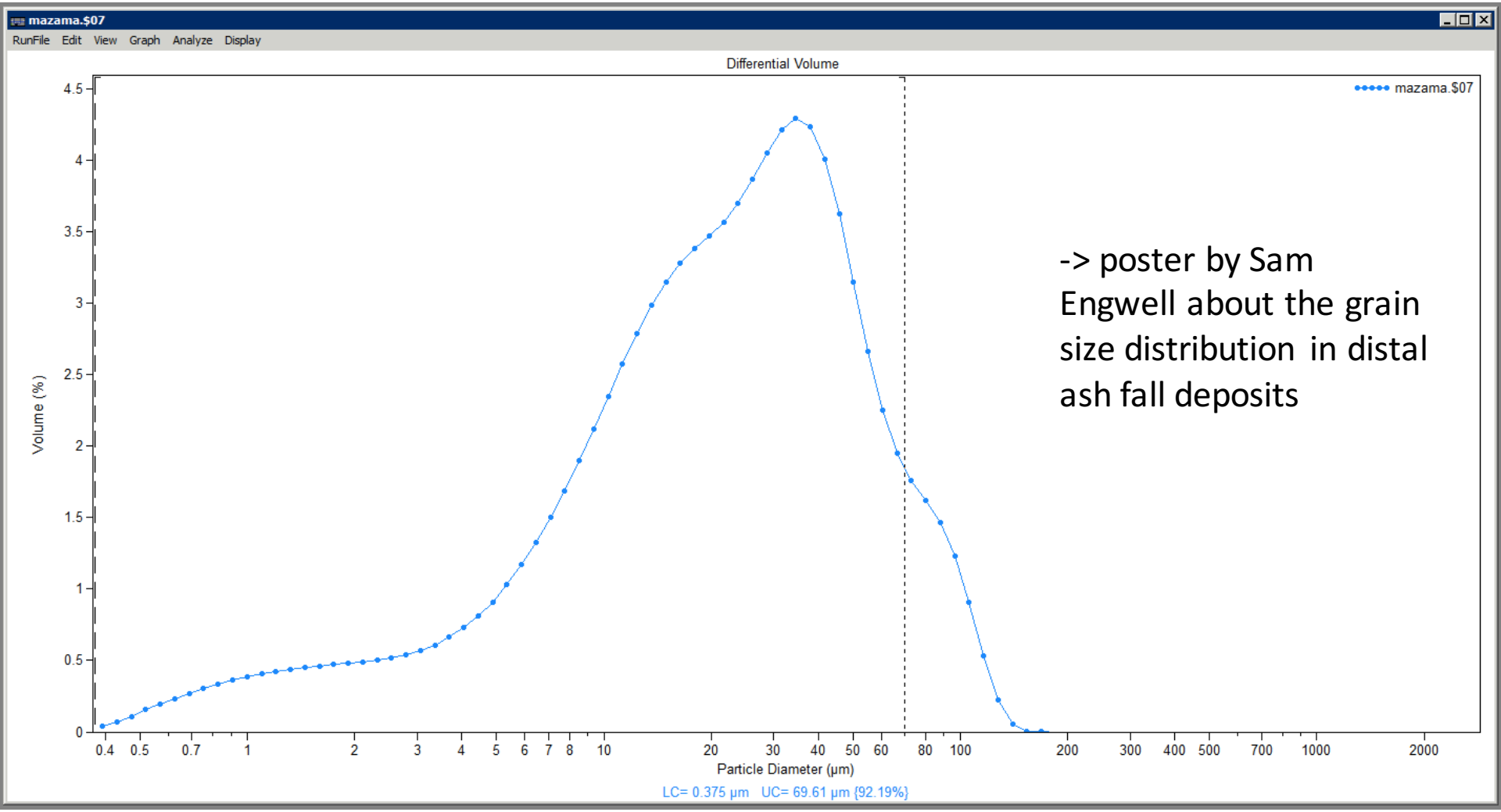
Song et al., 2014, EGU presentation

Grain size dependence on heating



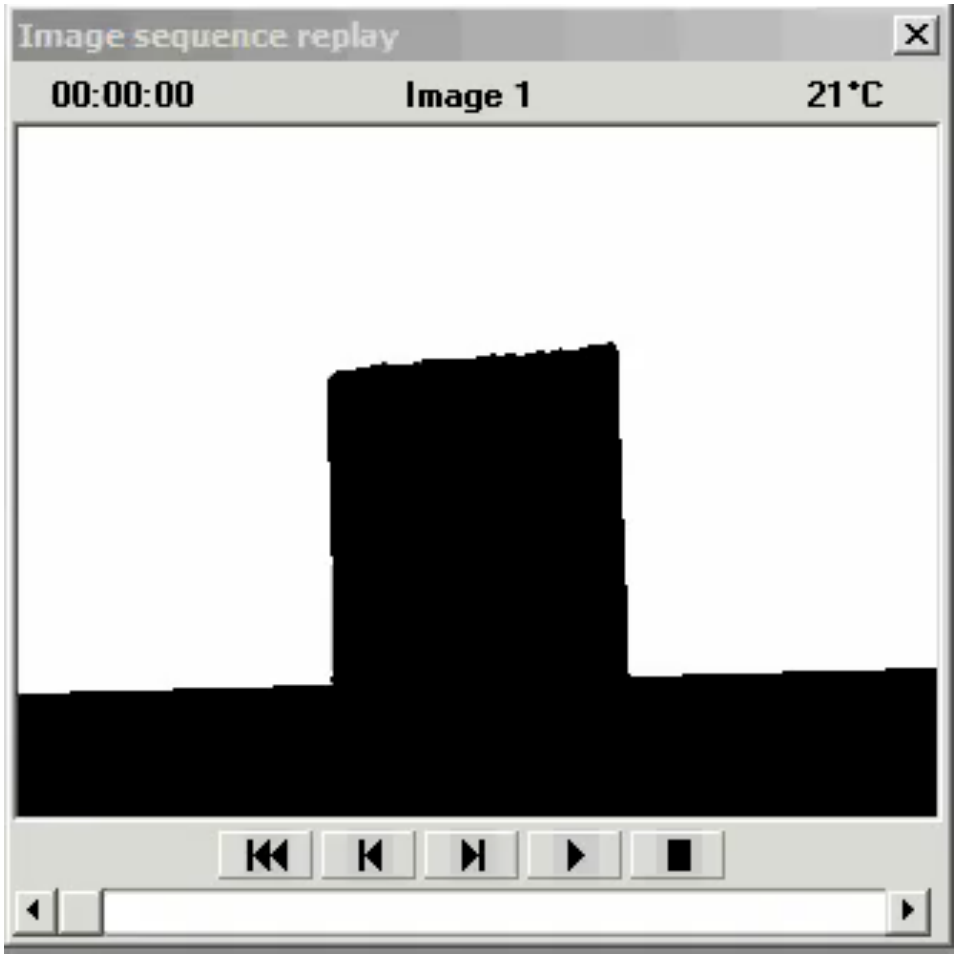
Wadsworth et al., 2014, JGR

Milled Mazama grain size distribution



-> poster by Sam Engwell about the grain size distribution in distal ash fall deposits

Mazama thermal behaviour (hot stage heating at 10 K/min)

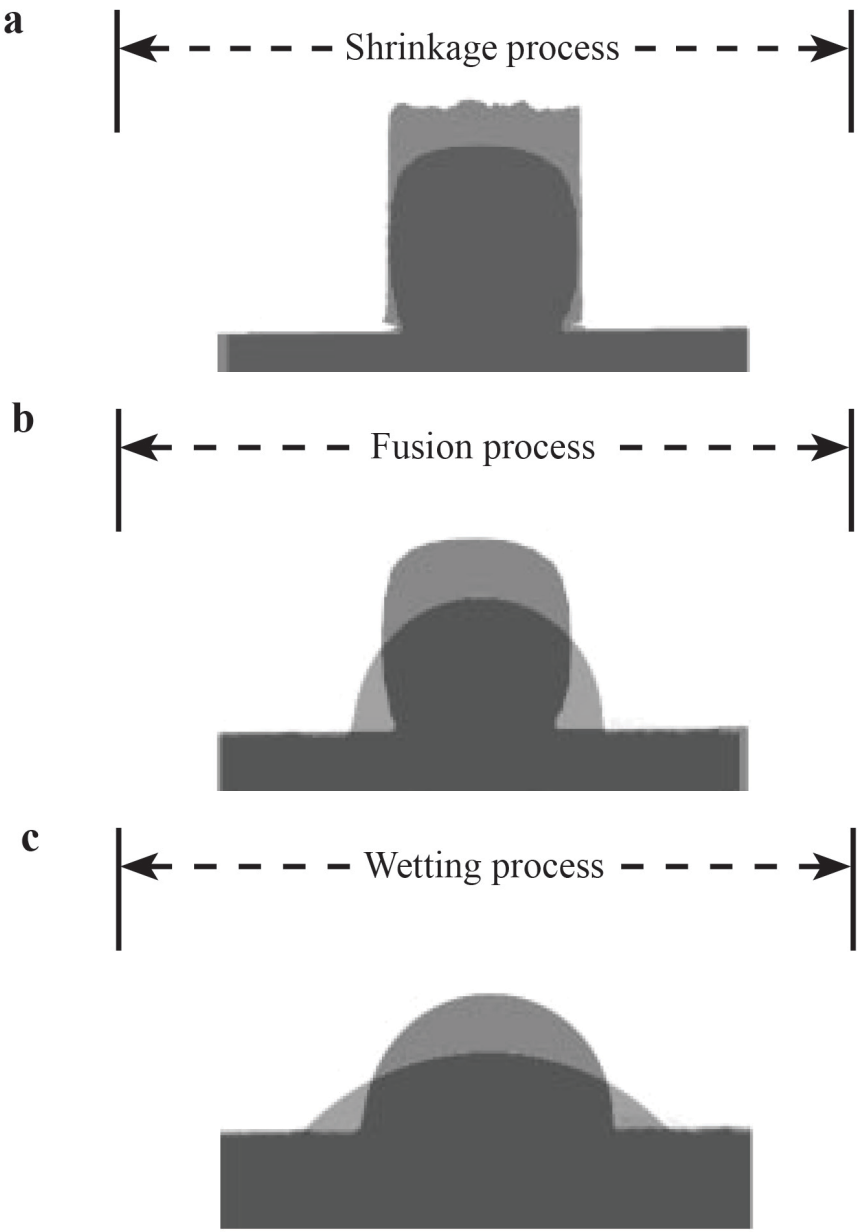


Rhyodacite of climactic eruption 7.700 y BP
70.5% SiO_2 (Tebbe, 2012)

900 – 1100 °C:
surface tension of the liquid drives densification as the particles coalesce

1100-1300 °C:
expansion of the bubbles
-> expansion of the sample

1300 °C:
gravity greater than surface tension
-> sample spreads under its own weight



Characteristic changes as viscosity decreases

Song et al., 2014 GRL

Thank you.

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