



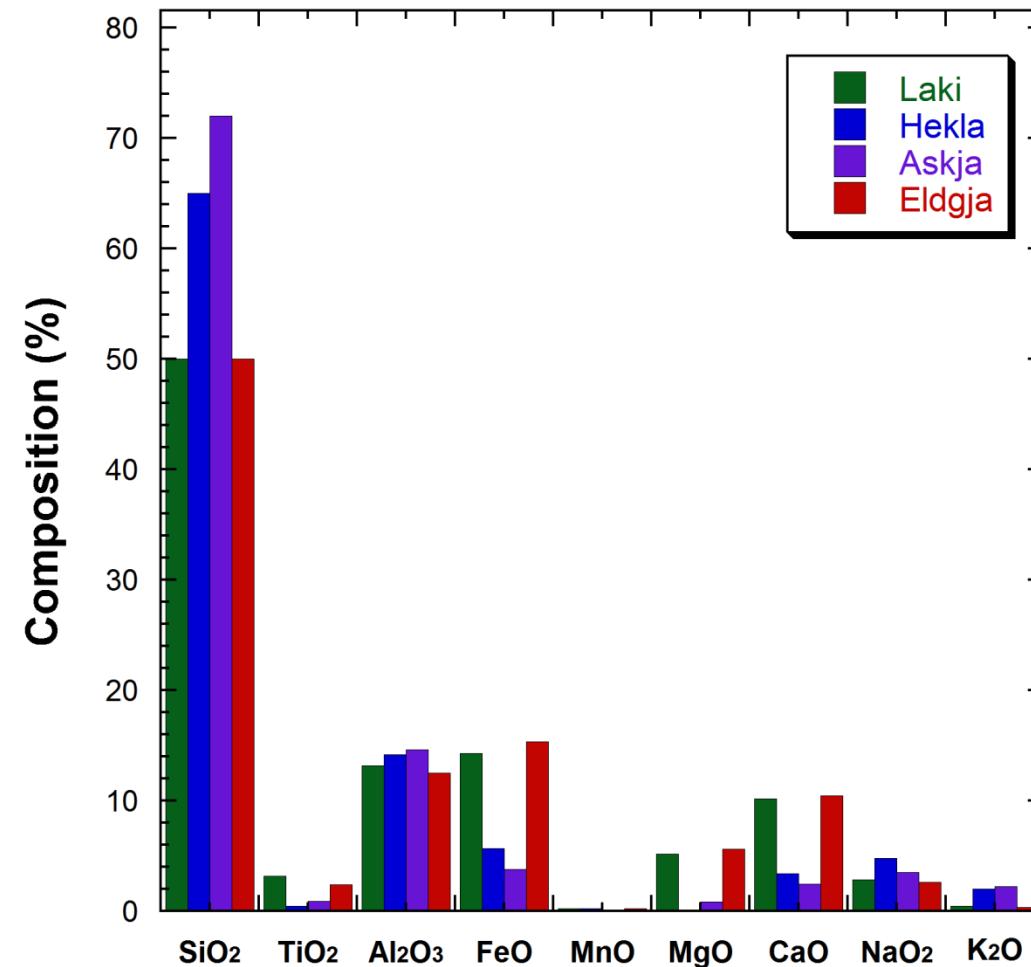
Deposition of volcanic ash in customised set-up for simulation of combustion chamber & turbine

C. Taltavull , K. A. Roberts, J. Dean, T.W. Clyne

2nd April, 2015, Cambridge



1. Composition of Ashes



All broadly similar but:

SiO₂ content:

Askja > Hekla > Laki ~ Eldgja

FeO content:

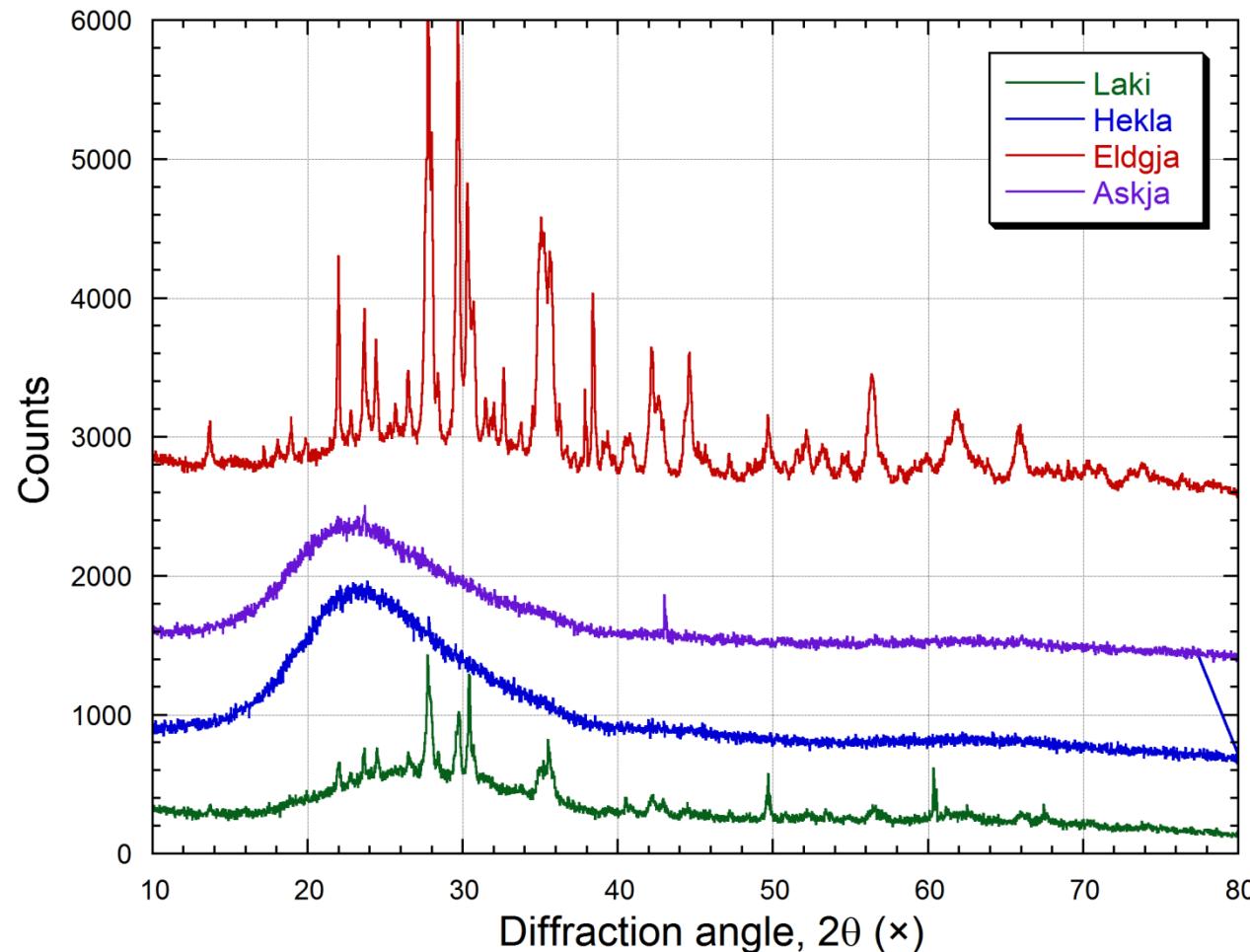
Eldgja ~ Laki > Hekla > Askja

CaO content:

Laki ~ Eldgja > Hekla ~ Askja



2. Glass content of Ashes

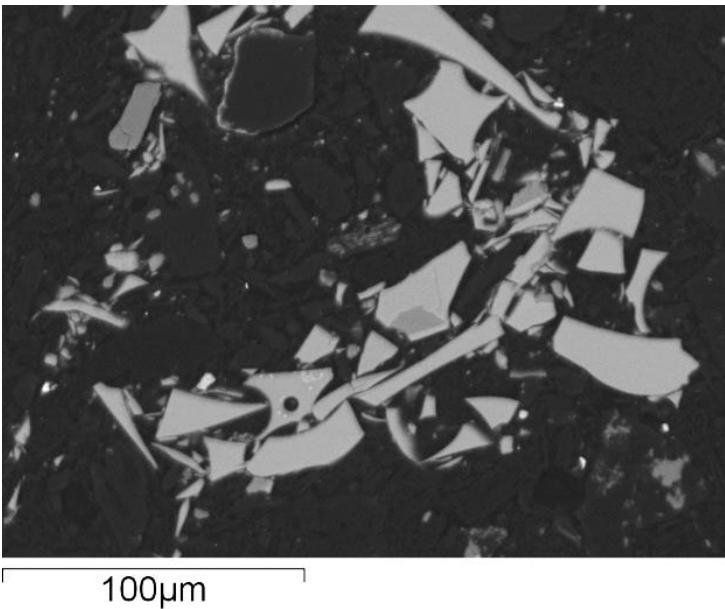


- Laki 70% amorphous
- Hekla 100% amorphous
- Askja 100% amorphous
- Eldgja 23% amorphous



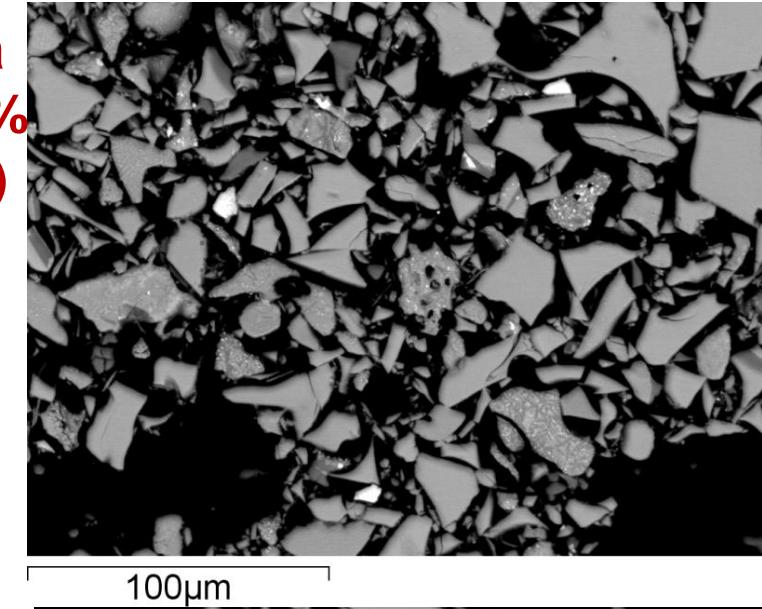
3. Particle shape of the Ashes (average PS ~ 25 μm)

Laki
(~ 70 %
Glass)



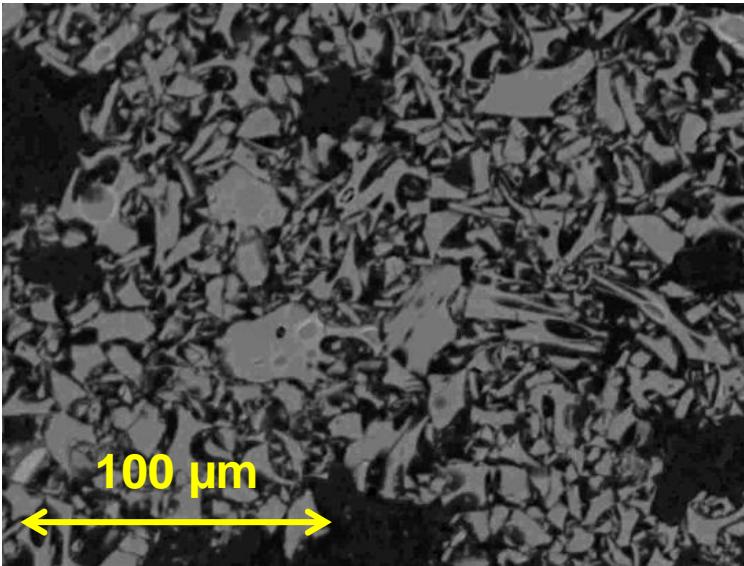
100μm

Eldgja
(~ 23 %
Glass)



100μm

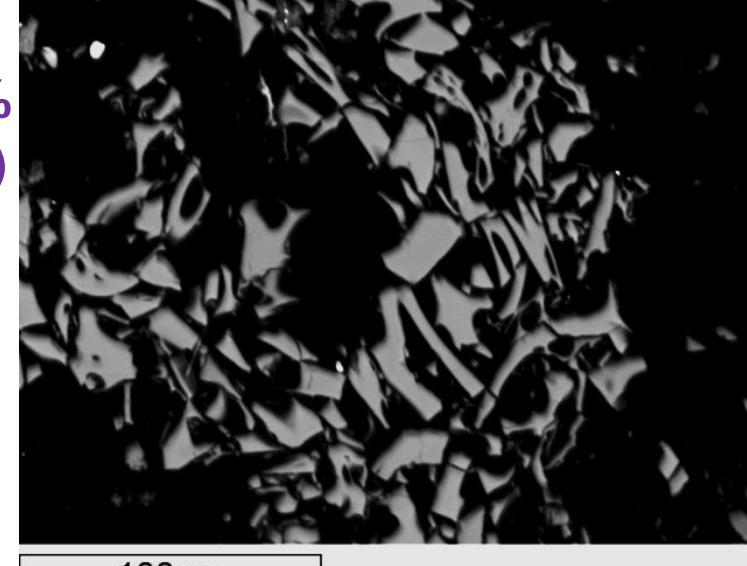
Hekla
(100 %
Glass)



100 μm



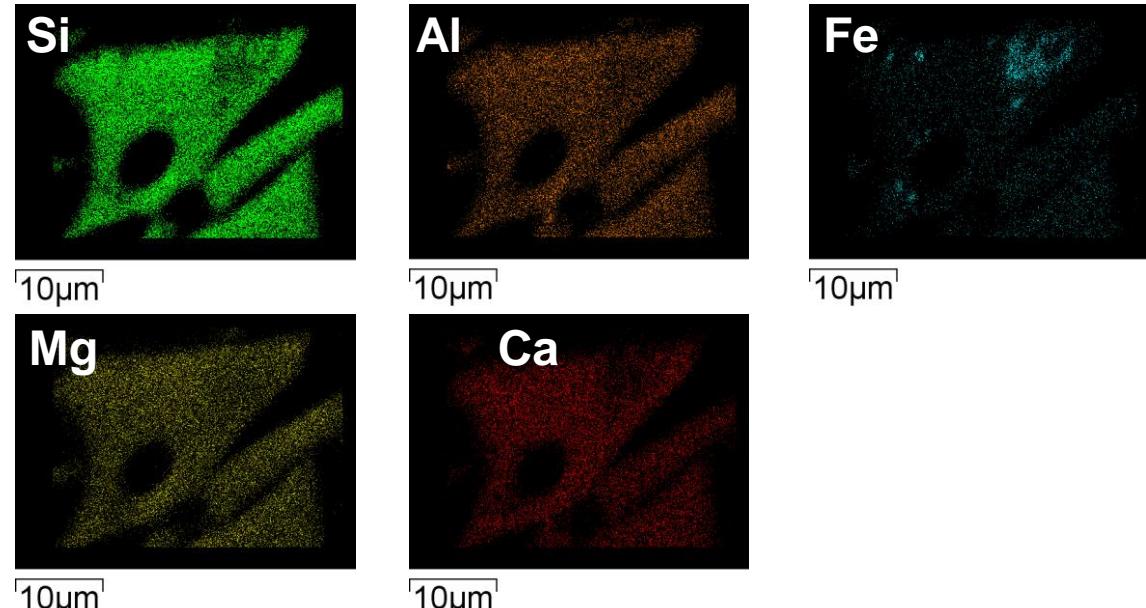
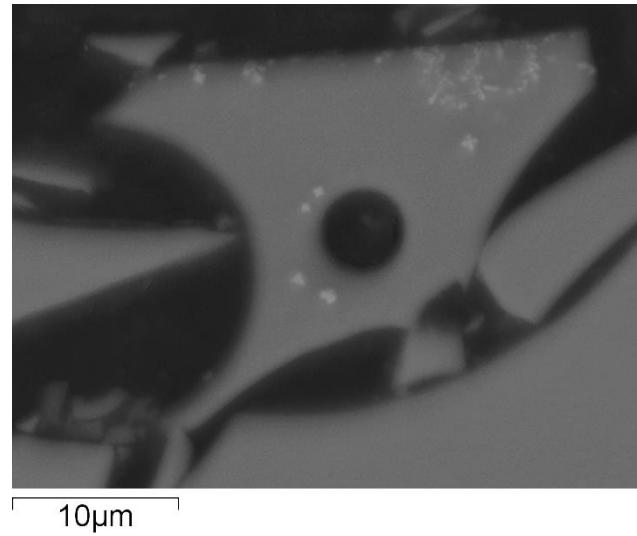
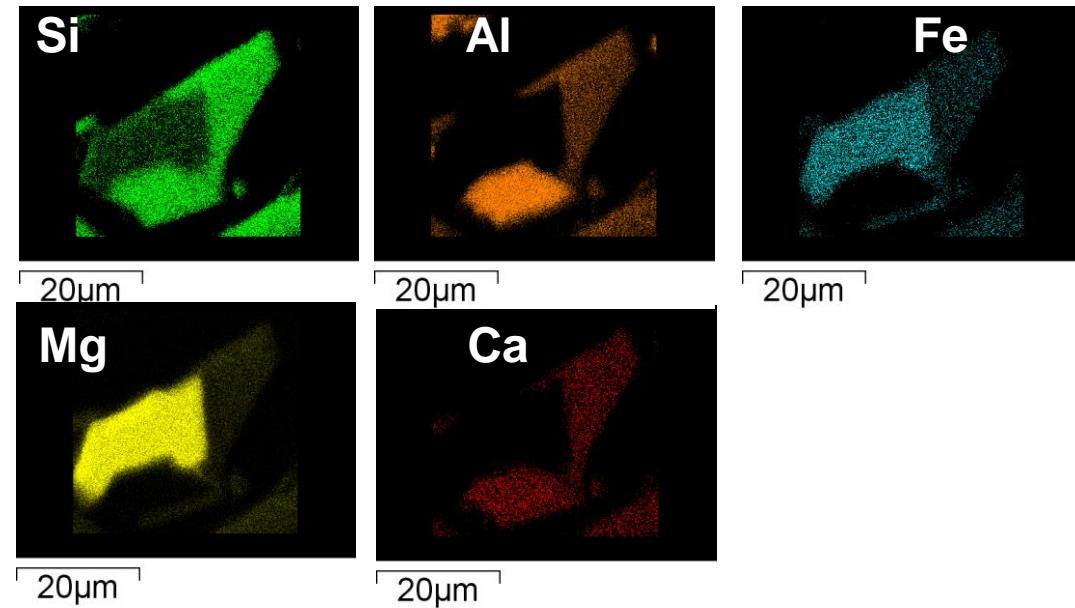
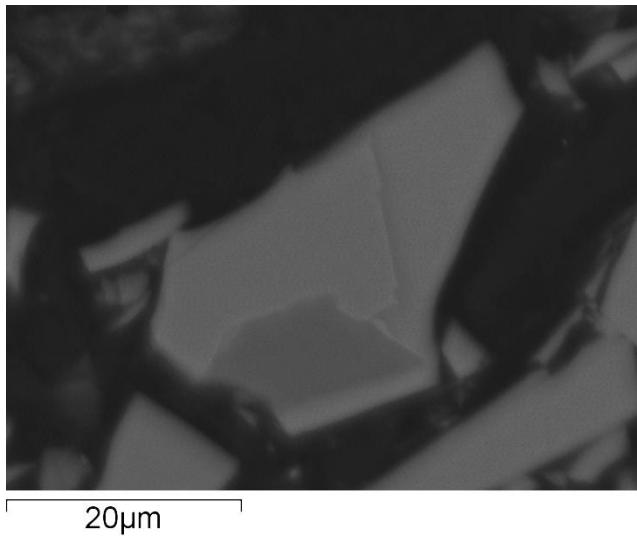
Askja
(100 %
Glass)



100μm

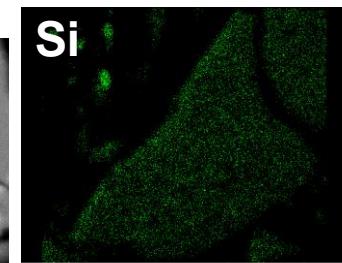
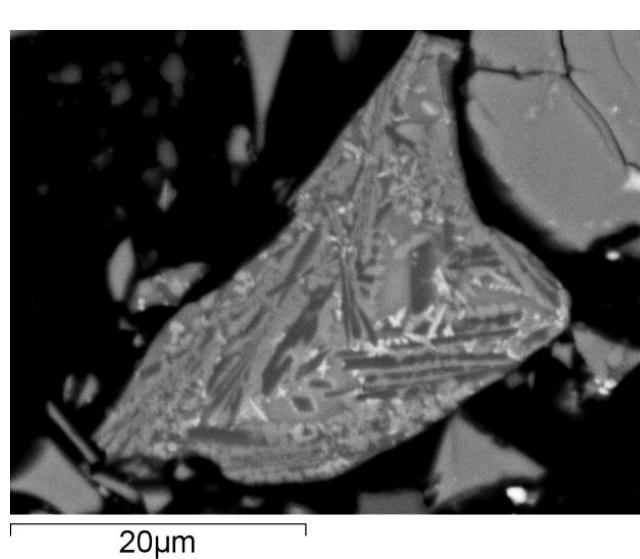


4. Phase distribution in Laki (~ 70 % glass)

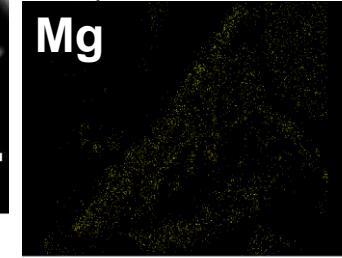




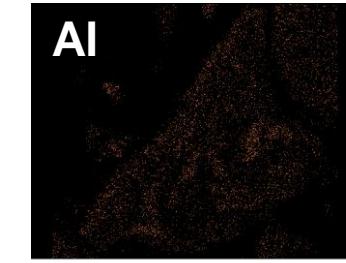
5. Phase distribution in Eldgja (~ 23 % glass)



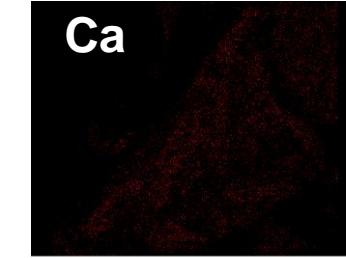
20µm



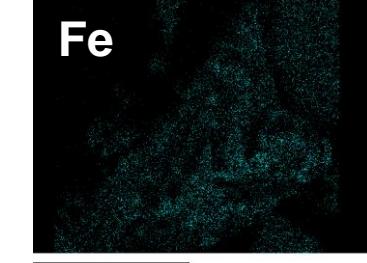
20µm



20µm



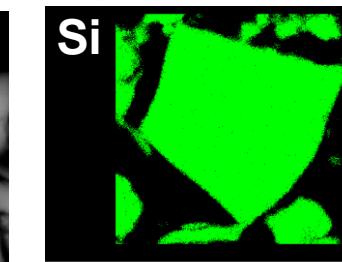
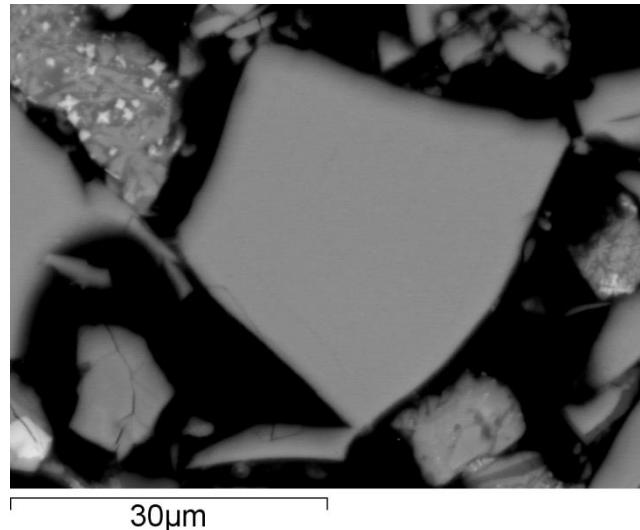
20µm



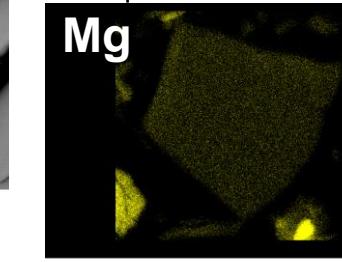
20µm



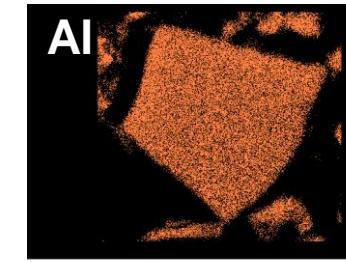
20µm



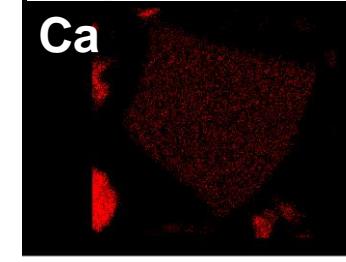
30µm



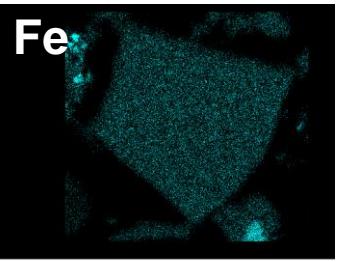
30µm



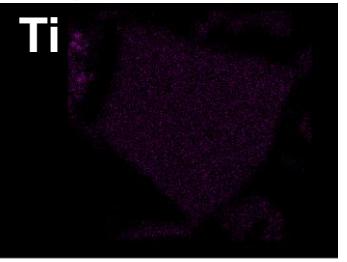
30µm



30µm



30µm

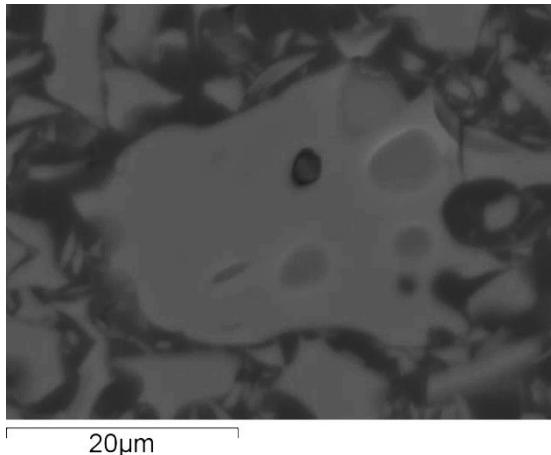


30µm

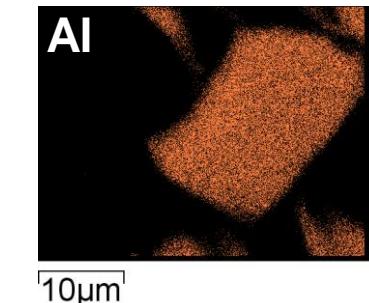
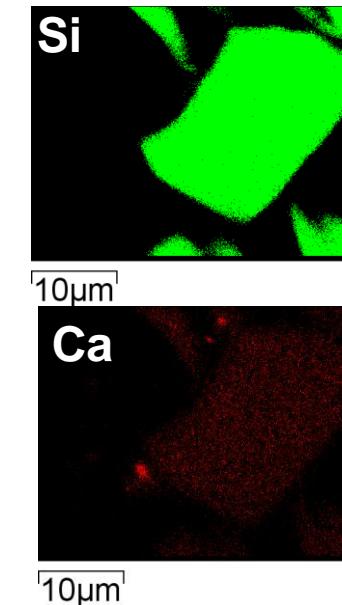
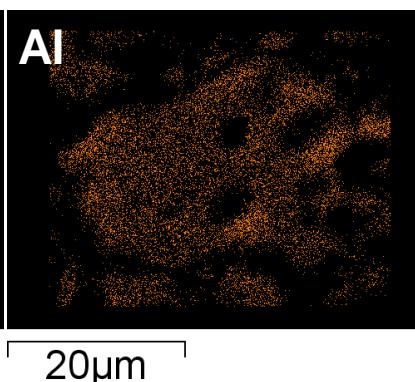
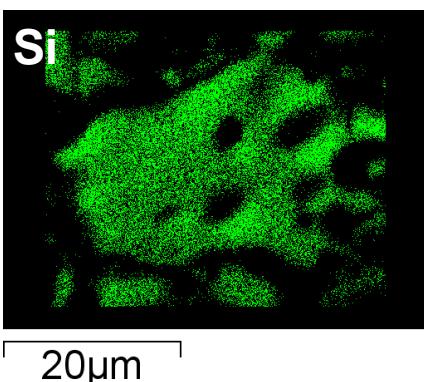
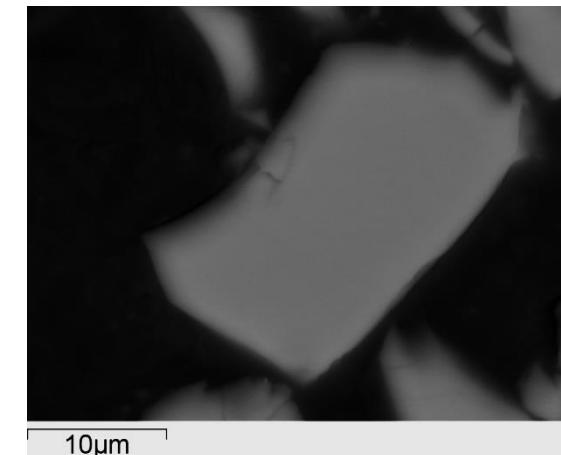


6. Phase distribution in Hekla and Askja

Hekla (100% glass)

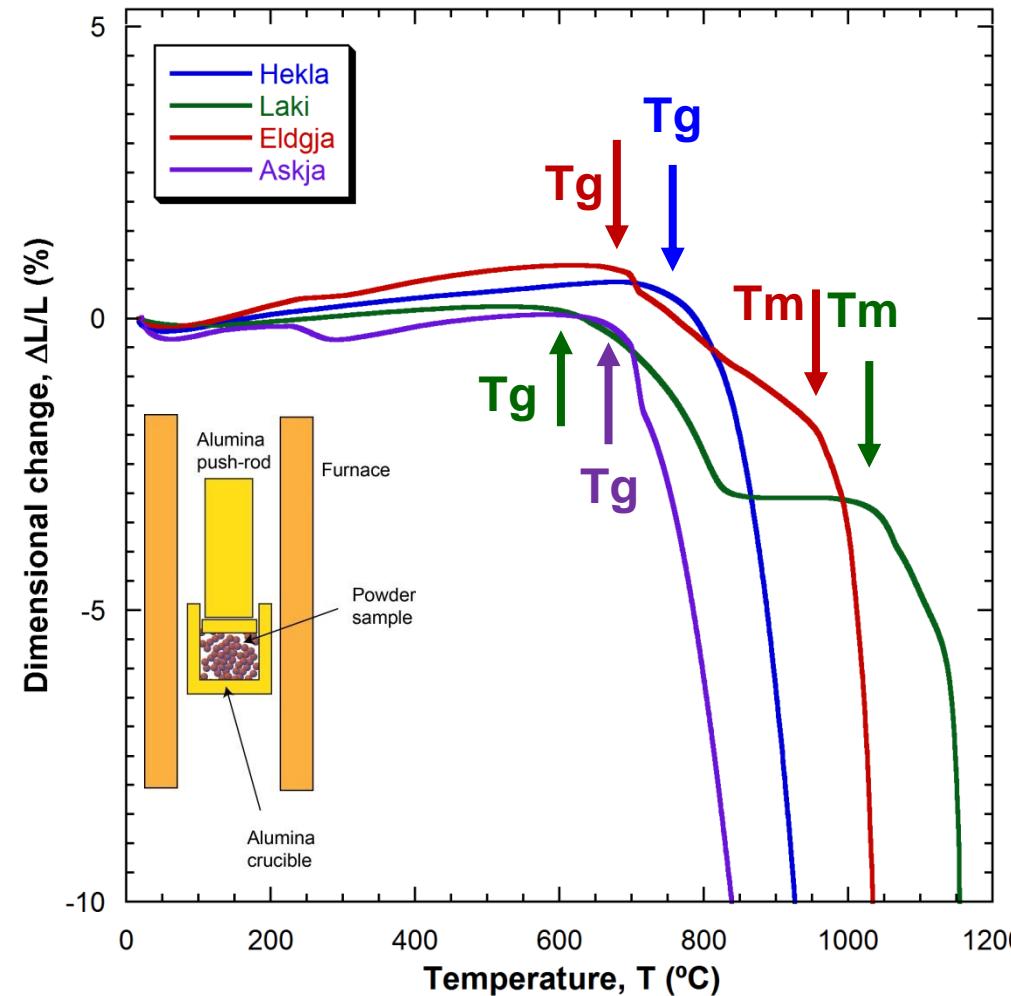


Askja (100 % glass)





7. T_g & T_m of the Ashes



- Laki

$T_g \text{ } 600\text{ }^{\circ}\text{C}$
 $T_m \text{ } 1100\text{ }^{\circ}\text{C}$

- Hekla

$T_g \text{ } 800\text{ }^{\circ}\text{C}$

- Eldgja

$T_g \text{ } 700\text{ }^{\circ}\text{C}$
 $T_m \text{ } 1000\text{ }^{\circ}\text{C}$

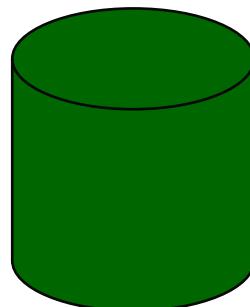
- Askja

$T_g \text{ } 700\text{ }^{\circ}\text{C}$



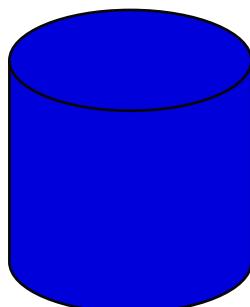
8. Densities of the Ashes

Compacted pellet



Densified under
pressure at
900 °C
for 30 min

Densified pellet



Density from
mass &
measured
dimensions
 $\rho = m/V$

Ash densities:

- Laki

2.0 mg mm⁻³

- Hekla

1.5 mg mm⁻³

- Eldgja

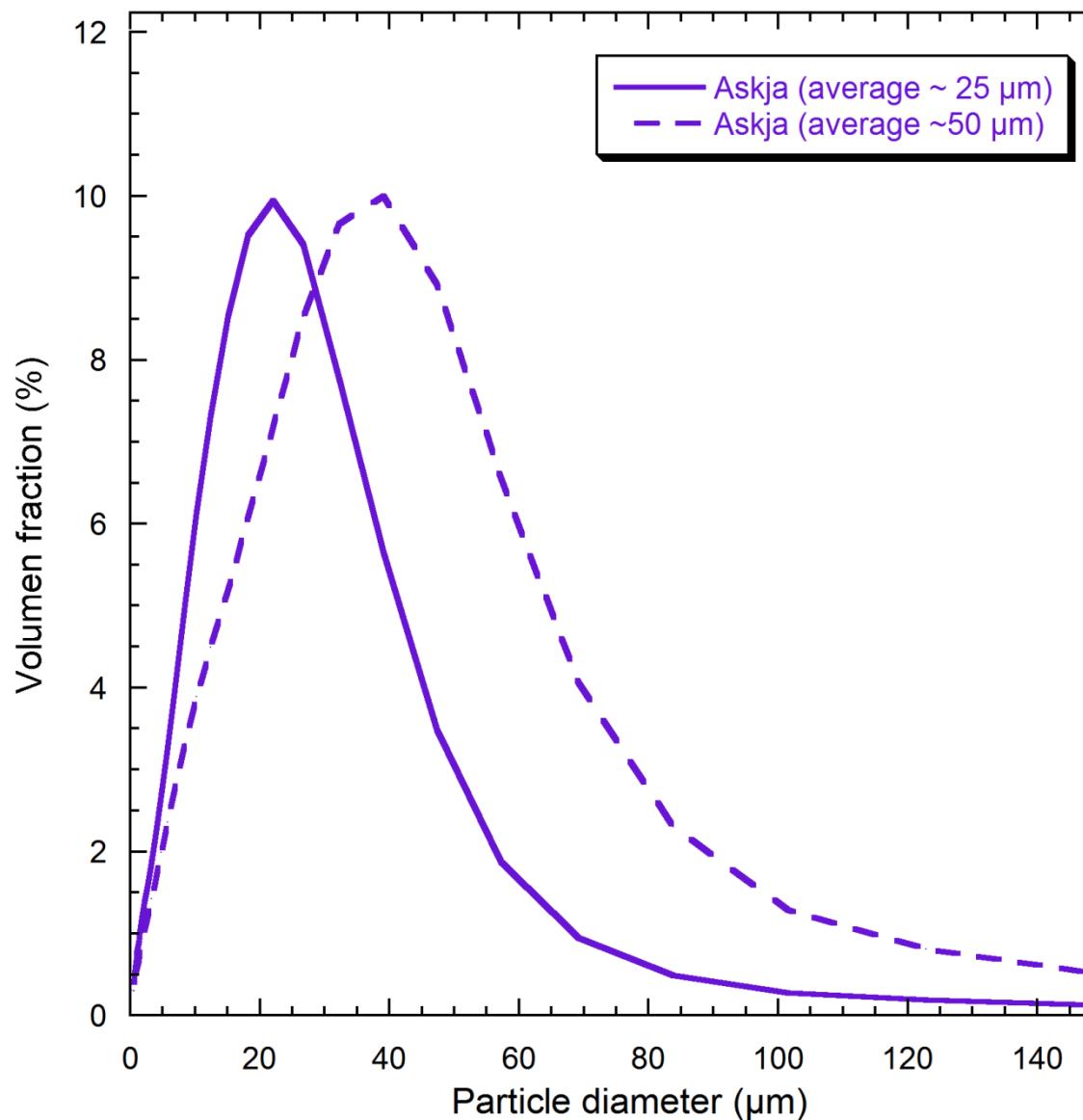
1.9 mg mm⁻³

- Askja

1.4 mg mm⁻³



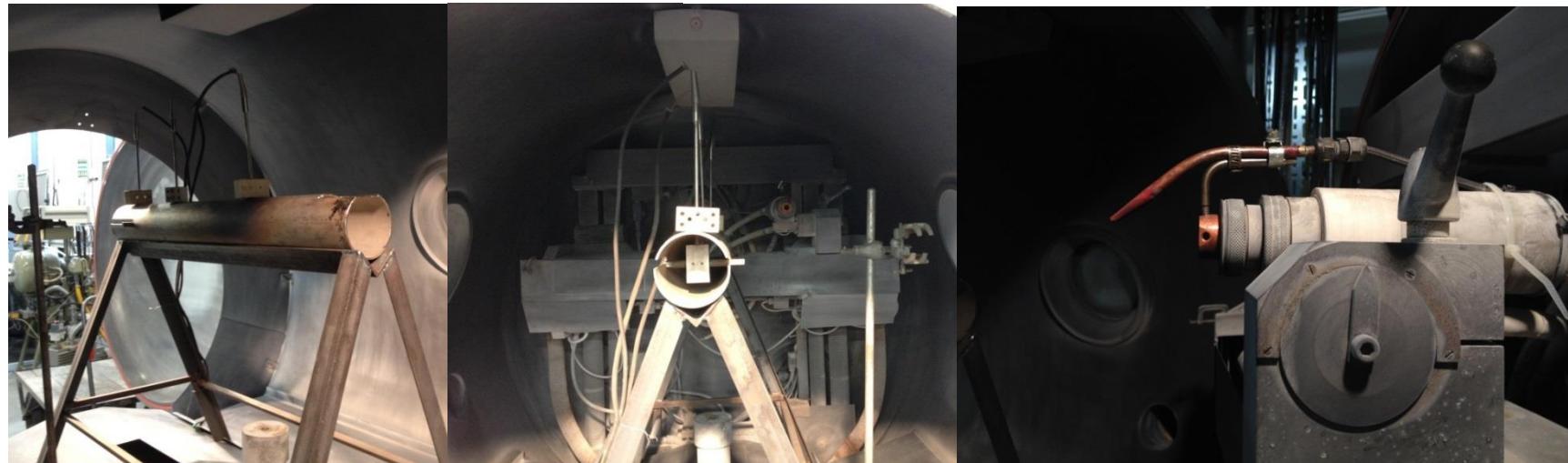
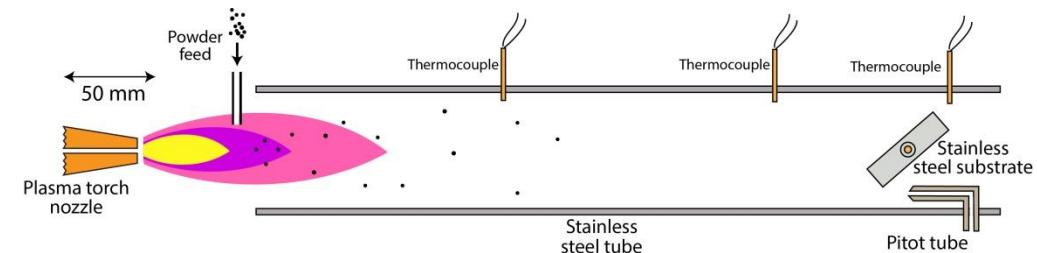
9. Particle size distribution of the Ashes





10. VPS customized set-up

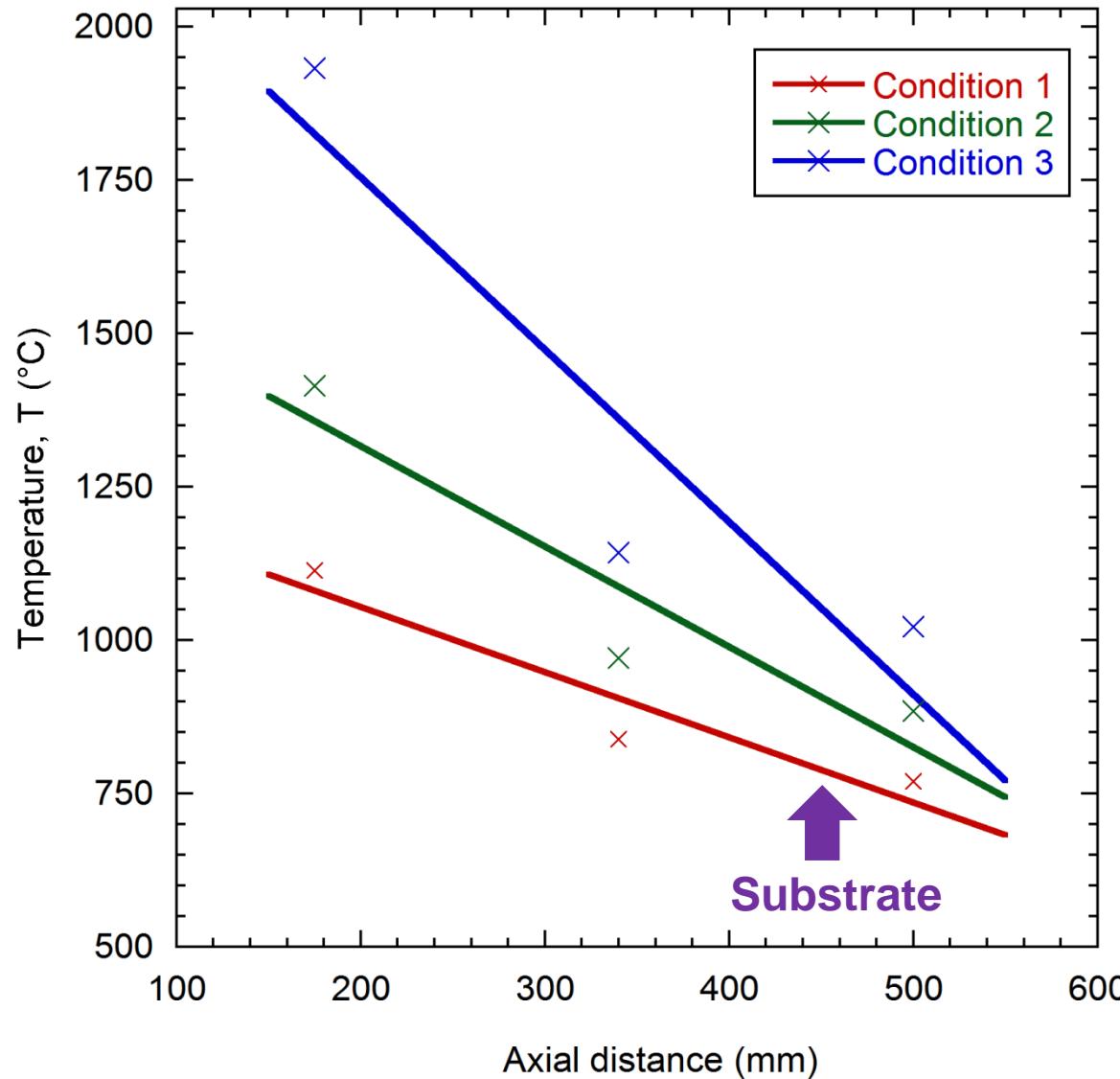
VPS customized set-up



Conditions	Power (kW)	Argon (L/min)	Hydrogen (L/min)	Current (A)	Pressure chamber
1	30	50	2	800	120 mbar
2	35	50	5	800	100 mbar
3	40	50	7	800	80 mbar



11. Axial Temperature profile for Ash Particle Injection



Gas T at
substrate position

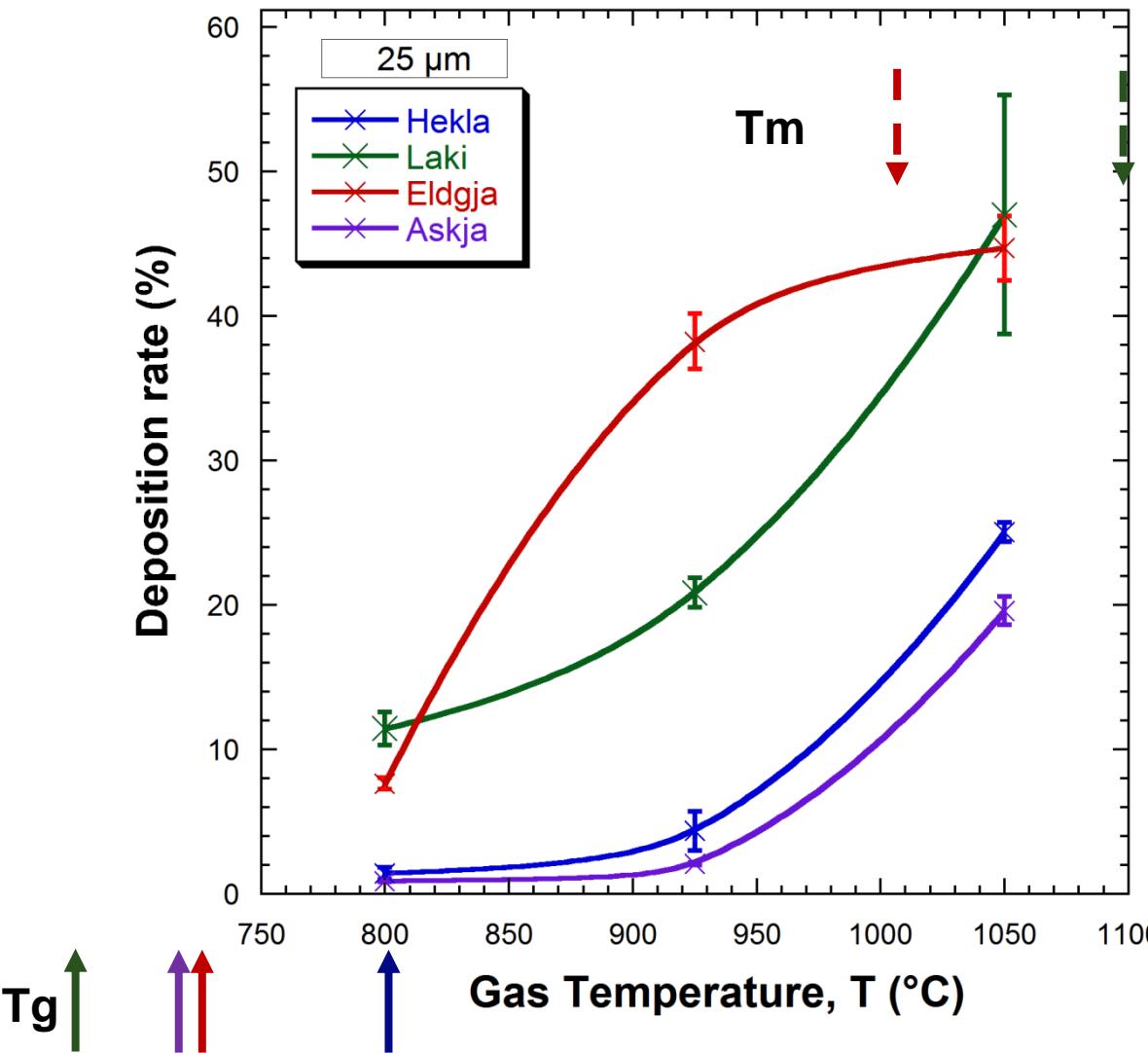
~ 800 °C

~ 925 °C

~ 1050 °C



12. Deposition rates of VA of particle size 25 μm



1. Deposition rate increases with T.

2. Deposition rate:
Eldgja ~Laki >Hekla ~ Askja

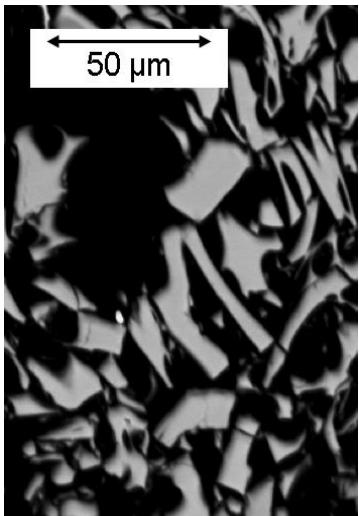
Consideration:

T_g rank (softening T):
Laki > Eldgja ~ Askja > Hekla

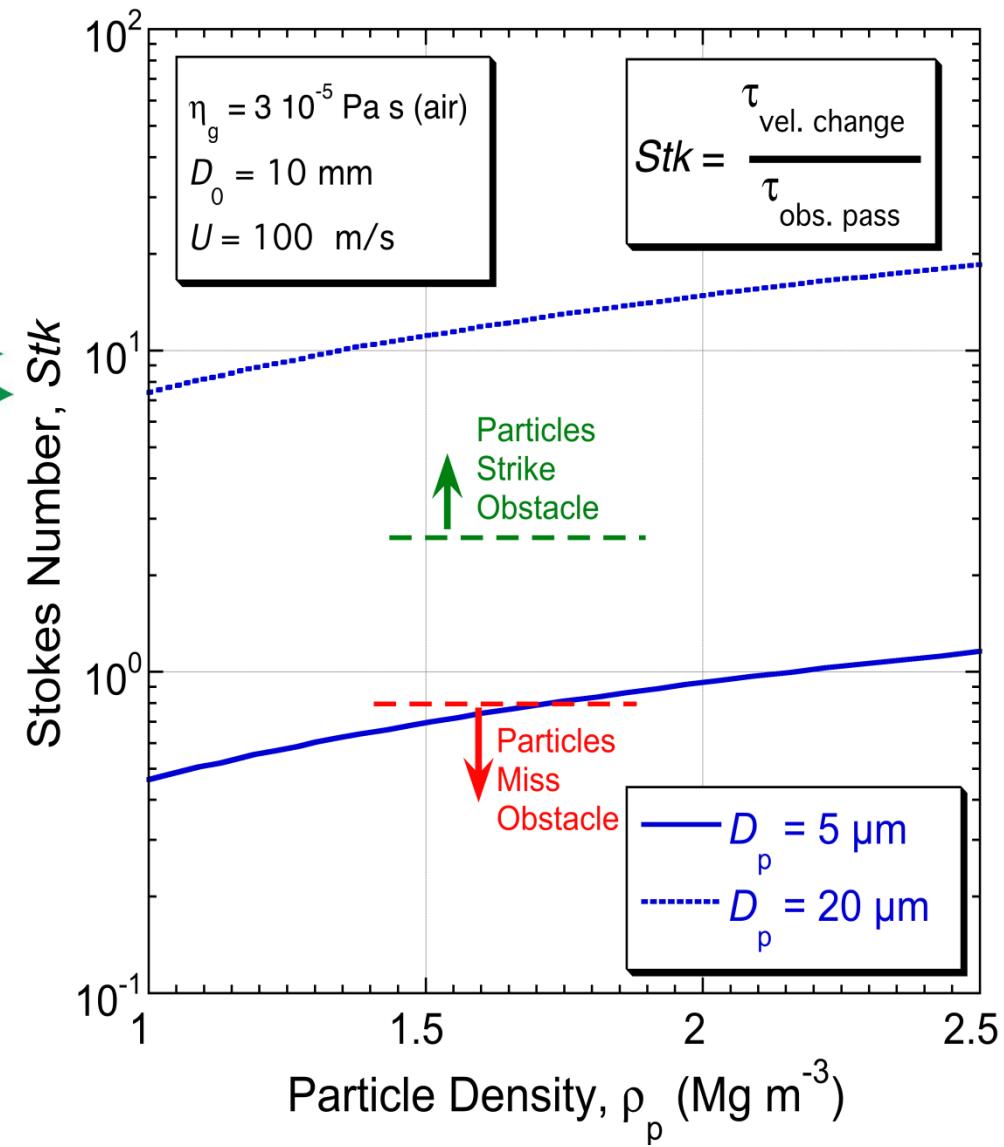
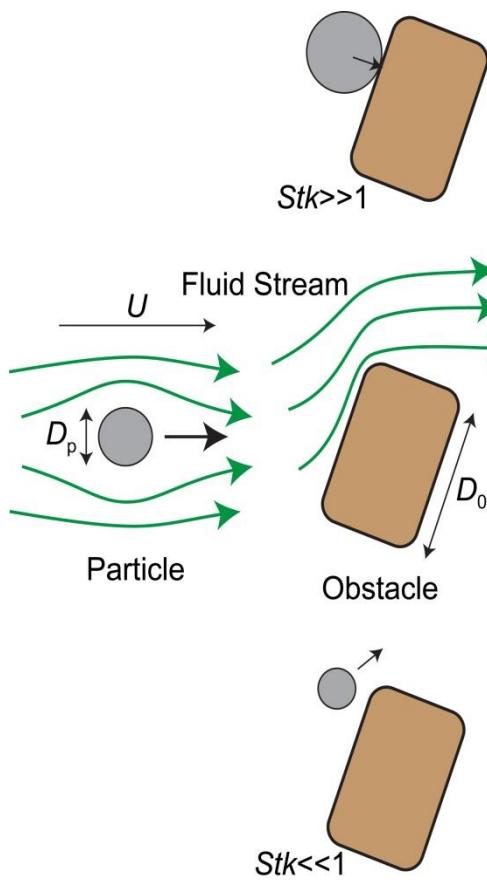
Ash densities:
Eldgja ~Laki >Hekla ~ Askja

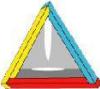


13. Effect of Particle Size and Density on the Stokes Number



**Polished
section of
(25 μm)
Askja
particulate**





14. Low magnification of deposited VA (particle size 25 µm)

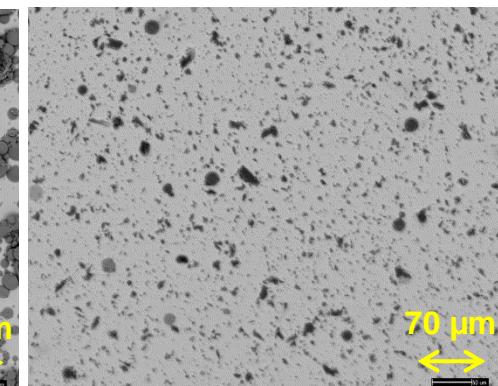
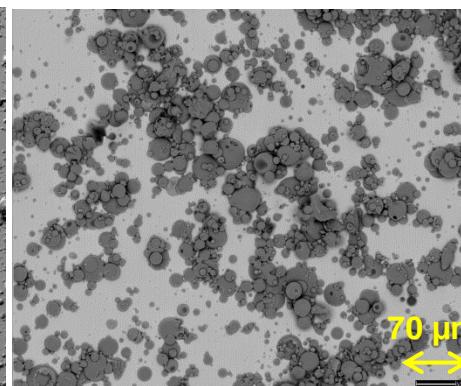
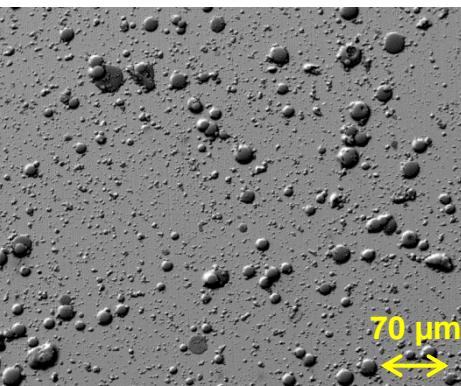
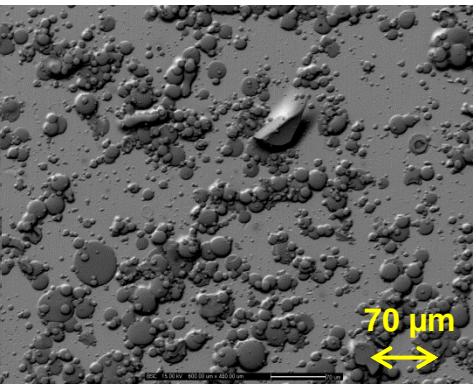
Laki

Hekla

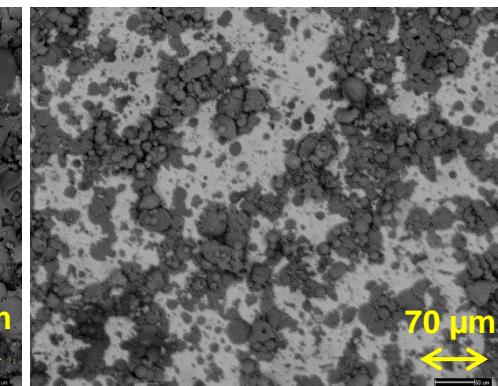
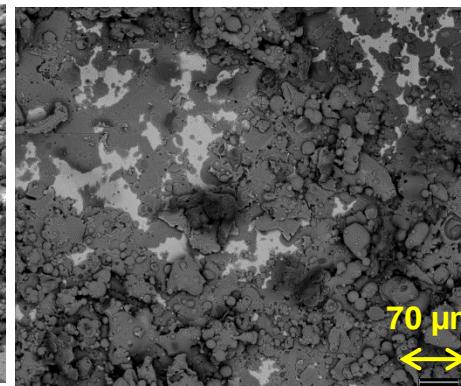
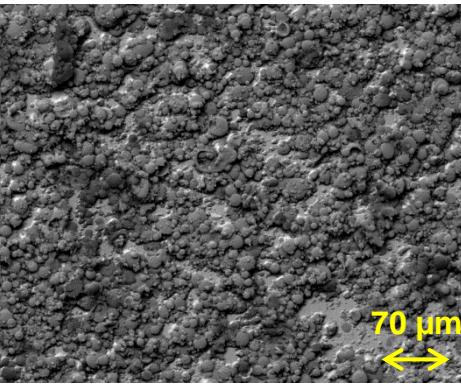
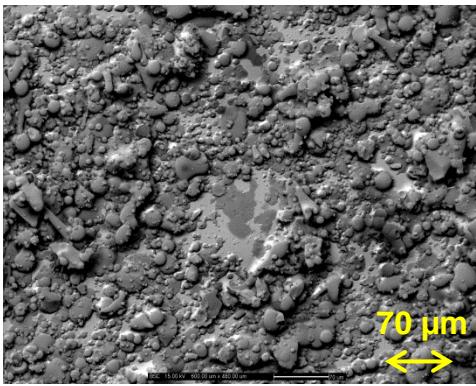
Eldgja

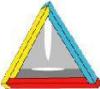
Askja

~ 800 °C



~ 1050 °C





15. Splat morphology of deposited VA (particle size 25 µm)

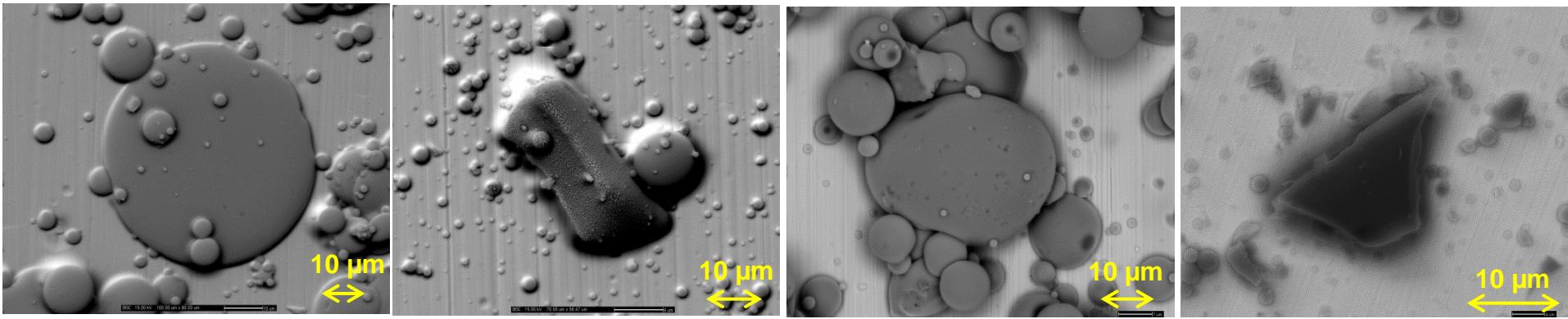
Laki

Hekla

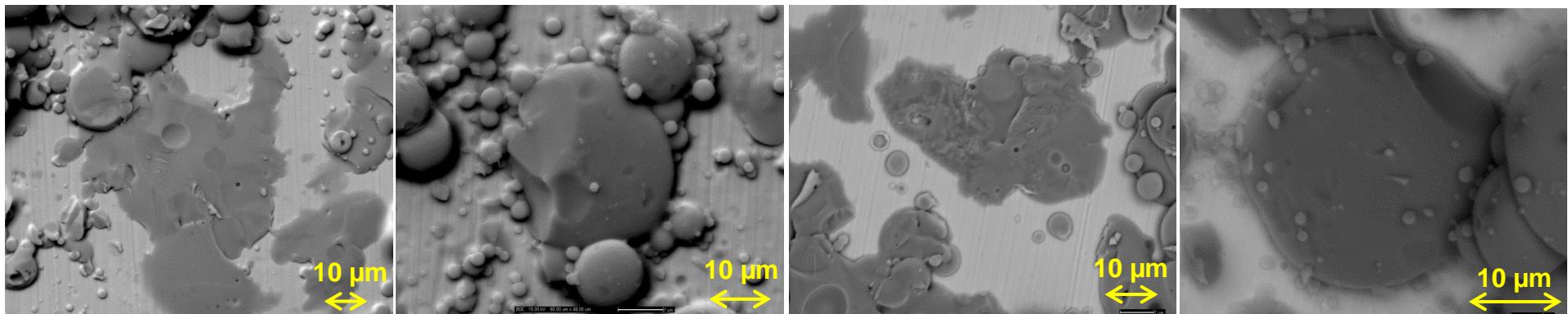
Eldgja

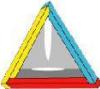
Askja

~ 800 °C



~ 1050 °C





16. Summary

- Eldgja and Laki tend to present a more equi-axed particle shape, compared with Hekla and Askja.
- Eldgja (~ 23% amorphous) shows a combination of fully amorphous and almost fully crystalline particles, whilst Laki (~ 70 % amorphous) is primarily amorphous particles with some crystalline phases. Hekla and Askja are fully amorphous.
- Eldgja and Laki densities are higher than Hekla and Askja because of higher Fe contents.
- Resistance to deposition ranking is: Askja ~ Hekla < Laki ~ Eldgja, although softening temperature ranking is: Laki > Eldgja ~ Askja > Hekla. Ash densities (Eldgja ~ Laki > Hekla ~ Askja) might affect the outcome, both for particles entering the plume and for deposition on the substrate. Low density (and flake-like shape) may explain, for example, the low deposition rate of Askja.