Constraining conditions for phreatic eruptions

and

evaluating the influence of hydrothermal alteration

on the process

an experimental approach

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Presentation outline

- Phreatic eruptions
- Field sites
- Methods
- First results
- Outlook

Phreatic eruptions

- in shallow confined hydrothermal systems
- heating of groundwater by rising magma
- vaporization of pore water to steam
- potential pressure build up (hydraulic barrier)

→ **phreatic explosion**

  – no involvement of juvenile material

  – often opening phase of phreatomagmatic or magmatic eruptions


Mount St. Helens

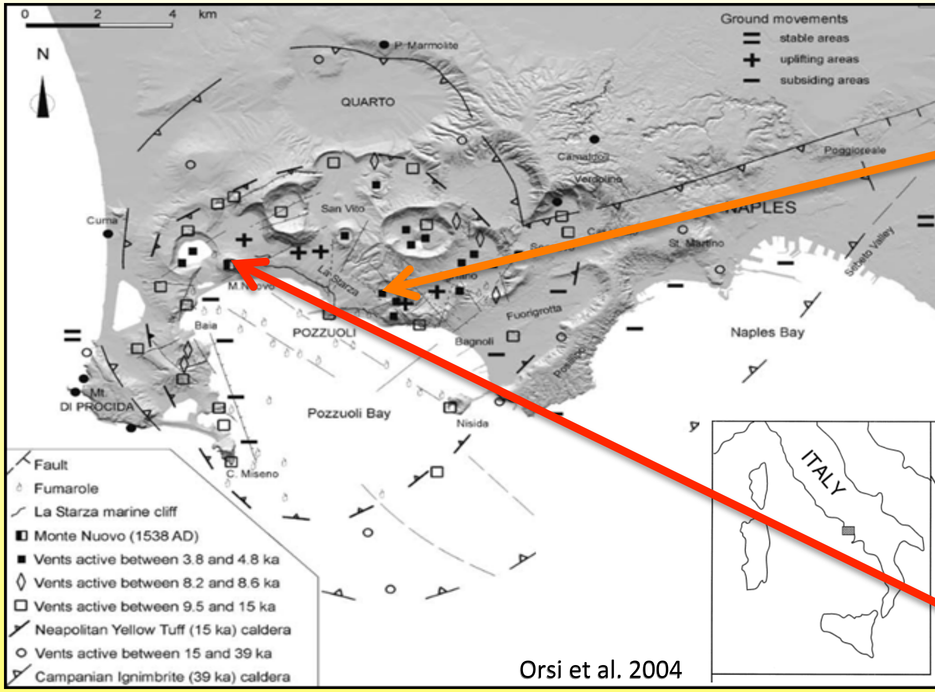
Field sites

- White Island *(New Zealand)*
- Solfatara & Monte Nuovo in Campi Flegrei *(Italy)*
- Valley of Desolation & Wotten Waven *(Dominica)*

⇒ characterised by intense **hydrothermal alteration**

⇒ high potential for future eruptions
(phreatic, phreatomagmatic or magmatic)

Campi Flegrei



Orsi et al. 2004

- Recent unrest episodes (‘69-’72 & ‘82-’84)
  (Orsi et al., 1996; Barberi et al., 1991)
- Last eruptions in 1198 and 1538
  (Scandone et al., 2010; Di Vito et al.)
- Intense fumarole and hot spring activity
  (Allard 1991)

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Dominica


Valley of Desolation


Wotten Waven

- Last phreatic eruptions in 1880 & 1997
  (Lindsay et al, 2005)
- Characterised by numerous hot springs and fumaroles
  (Edwards, 2009)

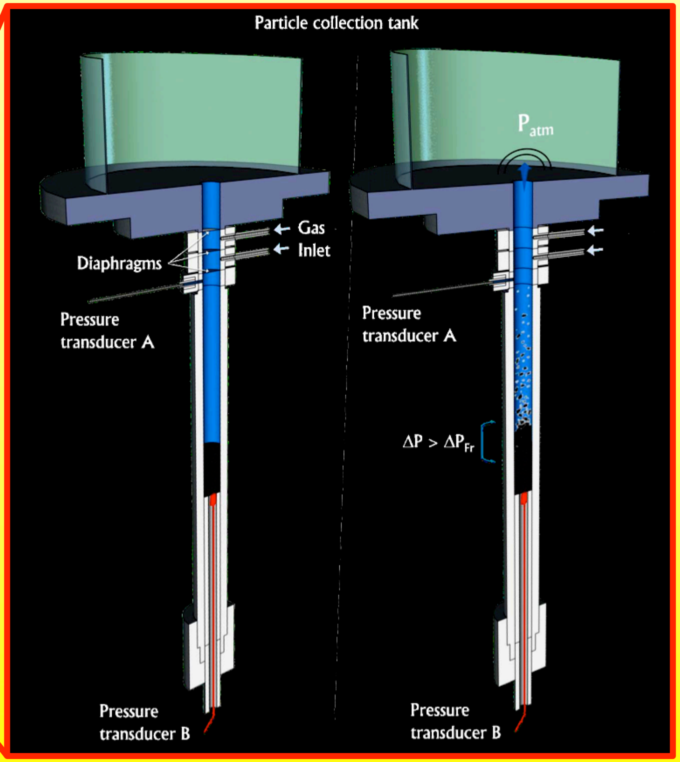
Methods

- Sample characterisation
  - Geochemical analysis (XRD, XRF, TGA,…)
  - Rock mechanical properties (permeability, porosity, UCS,...)

- Fragmentation experiments (shock tube apparatus)
  - Fragmentation threshold
  - Fragmentation efficiency
  - Ejection behaviour

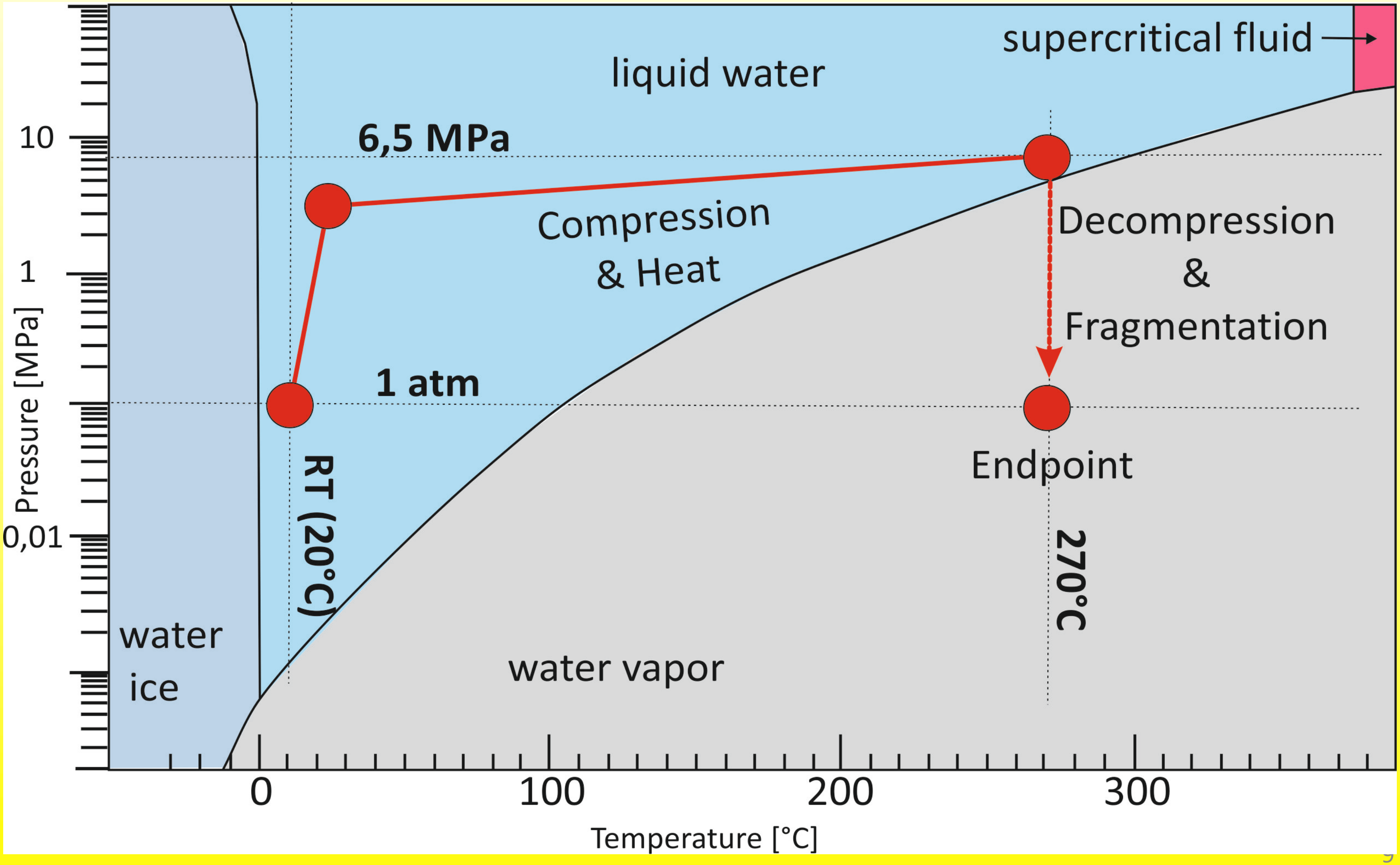
Experimental Setup

- dry & water saturated samples
- P-T conditions: 0.1 - 50 MPa & 20 - 300 °C
- full recovery of particles → GSD
- recording of particle ejection with high-speed camera

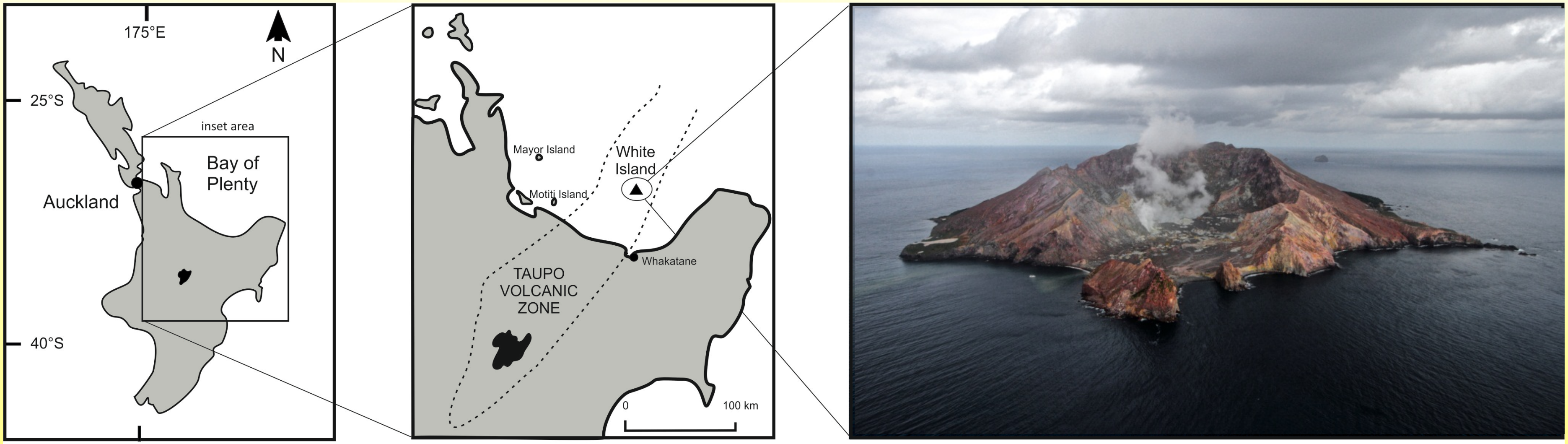


High-Pressure Autoclave

Experimental pathway



First results from White Island



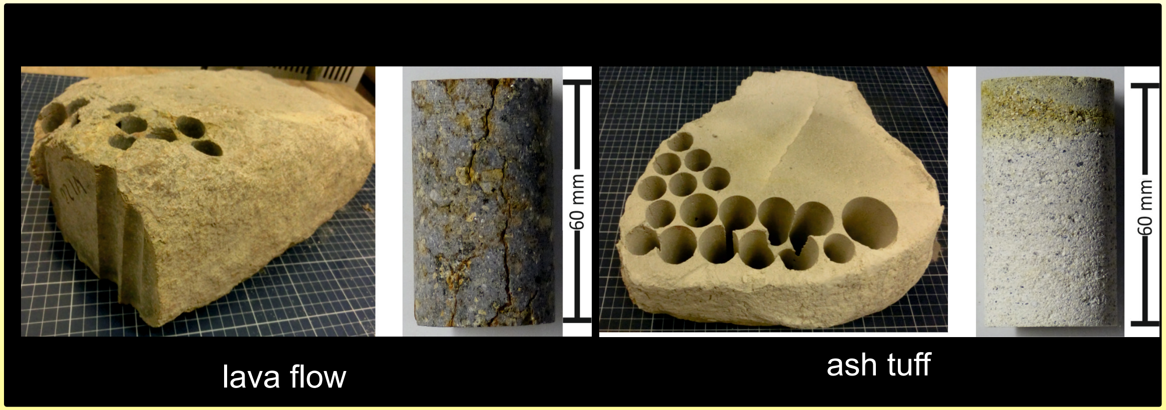
Location map showing White Island situated in the Taupo Volcanic Zone, New Zealand. (Photo taken by B. Scheu 2010)

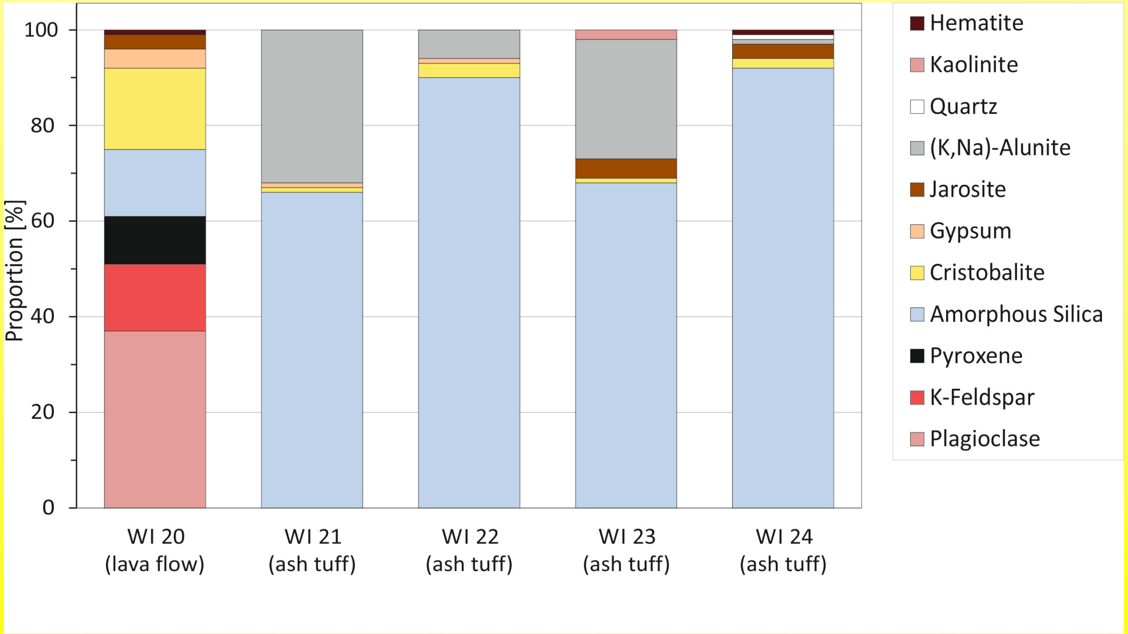
- New Zealand's most active volcano (last eruption August 2nd, 2012)
- characterised by phreatic and phreatomagmatic eruptions
- magma-water interaction due to active hydrothermal system
- intense alteration of the edifice

Samples from White Island

Consolidated samples
- lava flow
- ash tuff
- iron-rich crust
- sulfur-rich crust

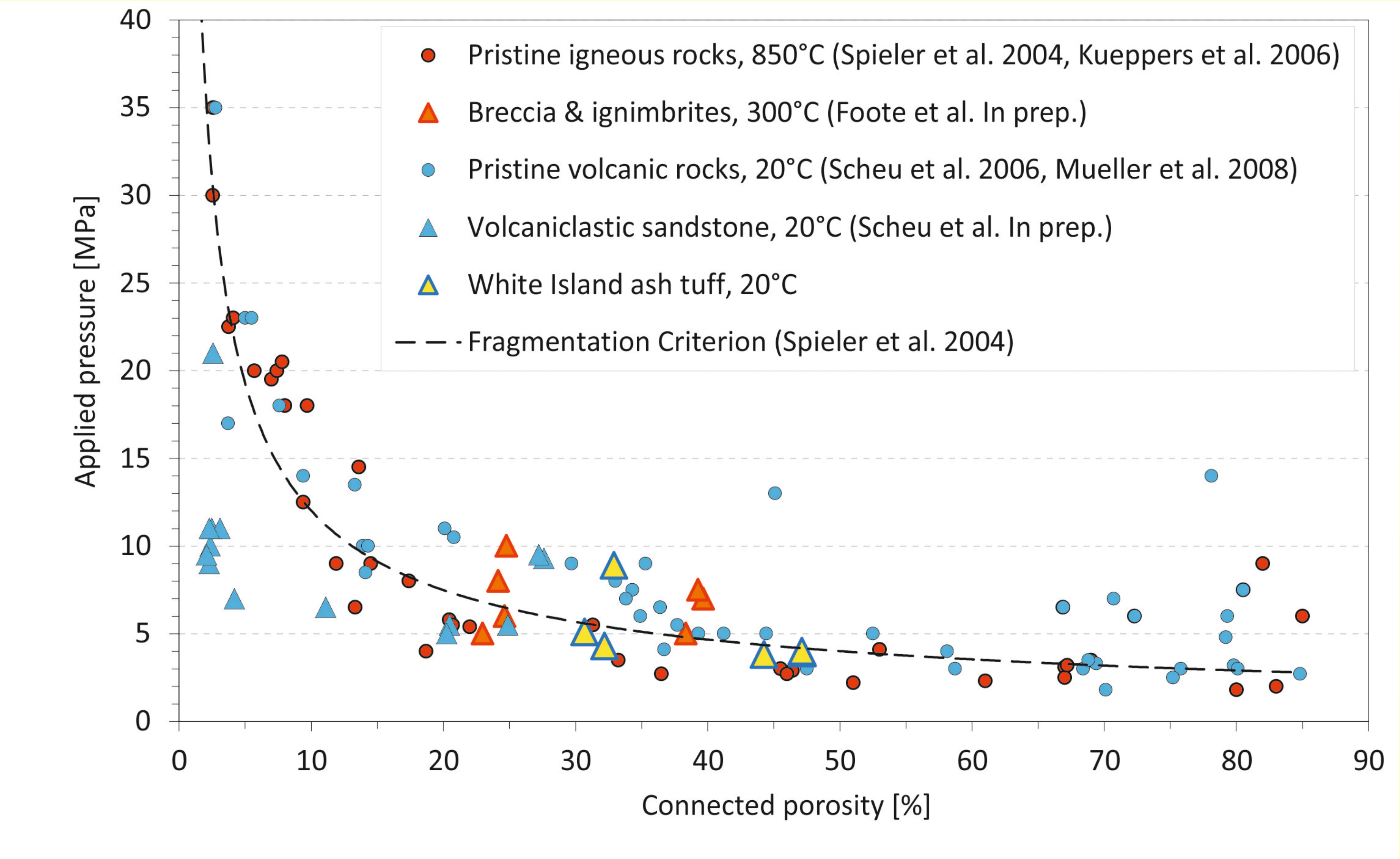
Unconsolidated samples
- ash/lapilli
- volcanic clay





XRD data of samples (WI 20 - WI24)

Fragmentation threshold

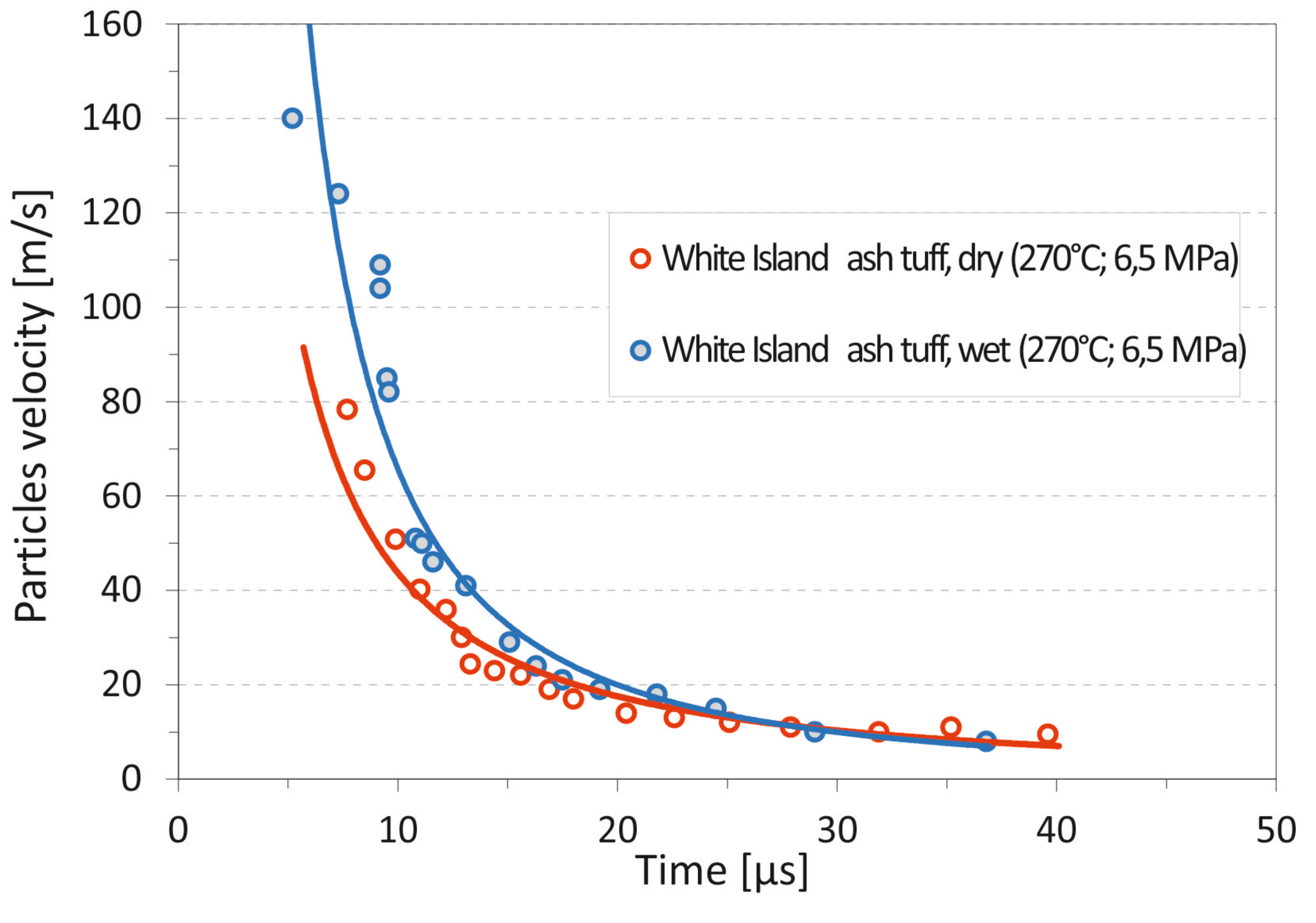


High speed video

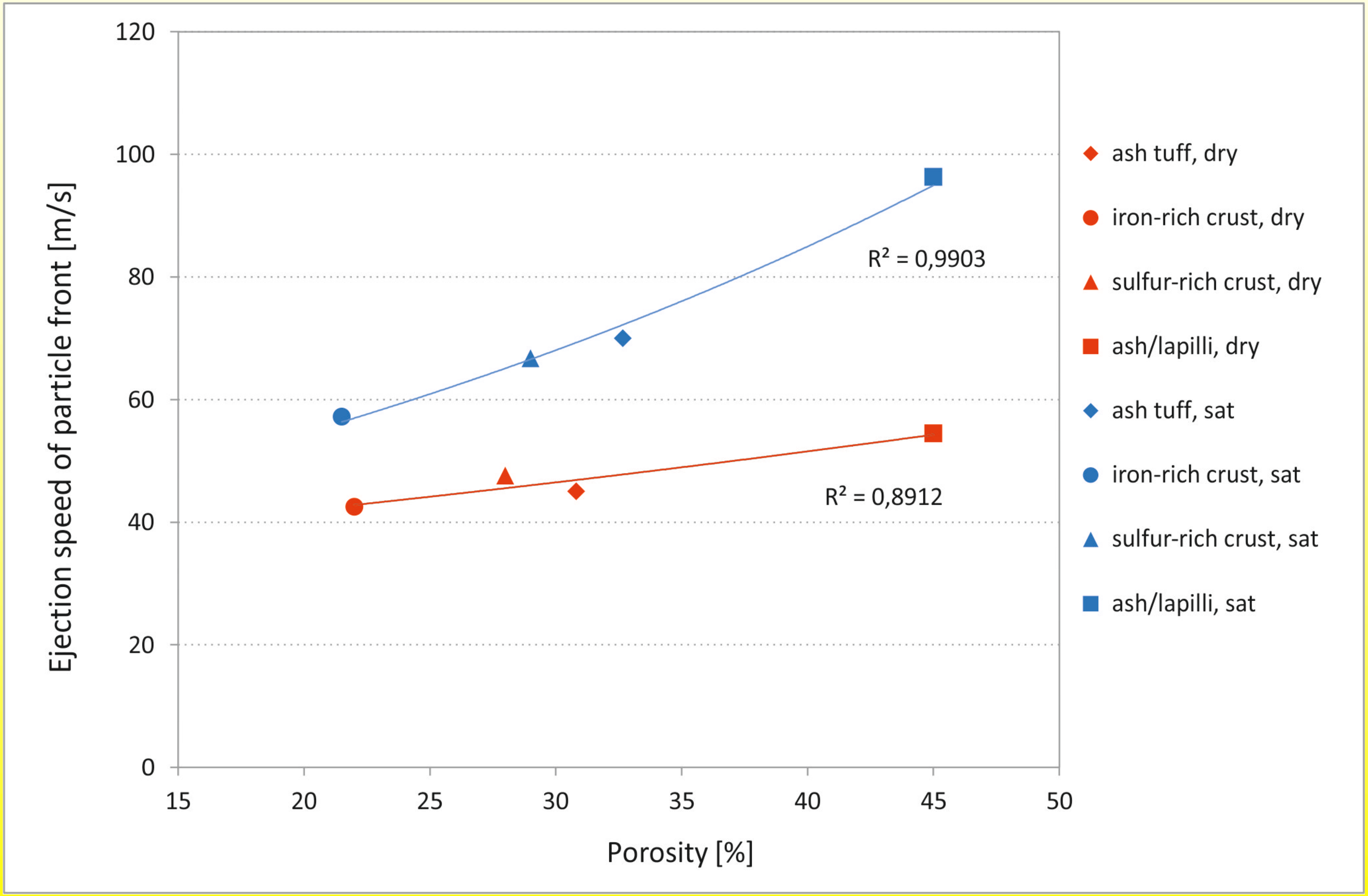
- White Island ash tuff
- 34% (open porosity)
- 100% water saturated
- $T_{fragmentation}$: 270°C
- $P_{fragmentation}$: 6,5 MPa

High speed video

Ejection behaviour



Ejection behaviour



Conclusions

- White Island samples confirm that

  open porosity controls the fragmentation threshold

  initial pressure controls the fragmentation efficiency

- Ejection velocity increases with water saturation of samples

- Rock mechanical data shows that alteration is weakening the rocks

Outlook

- Finish experiments with White Island samples
- Apply the lessons from White Island to samples from Campi Flegrei & Dominica
- Influence of alteration on fragmentation efficiency

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Thank you!