

The disappearance of pseudotachylytes from the geological record: mineralogy and geochemistry

*La scomparsa delle pseudotachiliti dal record geologico:
mineralogia e geochimica.*



**DIPARTIMENTO
DI GEOSCIENZE**

FRANCESCO GOSIO
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**UNIVERSITÀ
DEGLI STUDI
DI PADOVA**

Relatore: **Giulio Di Toro**
Correlatore: **Michele Fondriest**

Outline of the thesis

1. Motivations

2. Methods

3. Artificial pseudotachylytes

3.1 Fresh pseudotachylytes

3.2 Altered pseudotachylytes

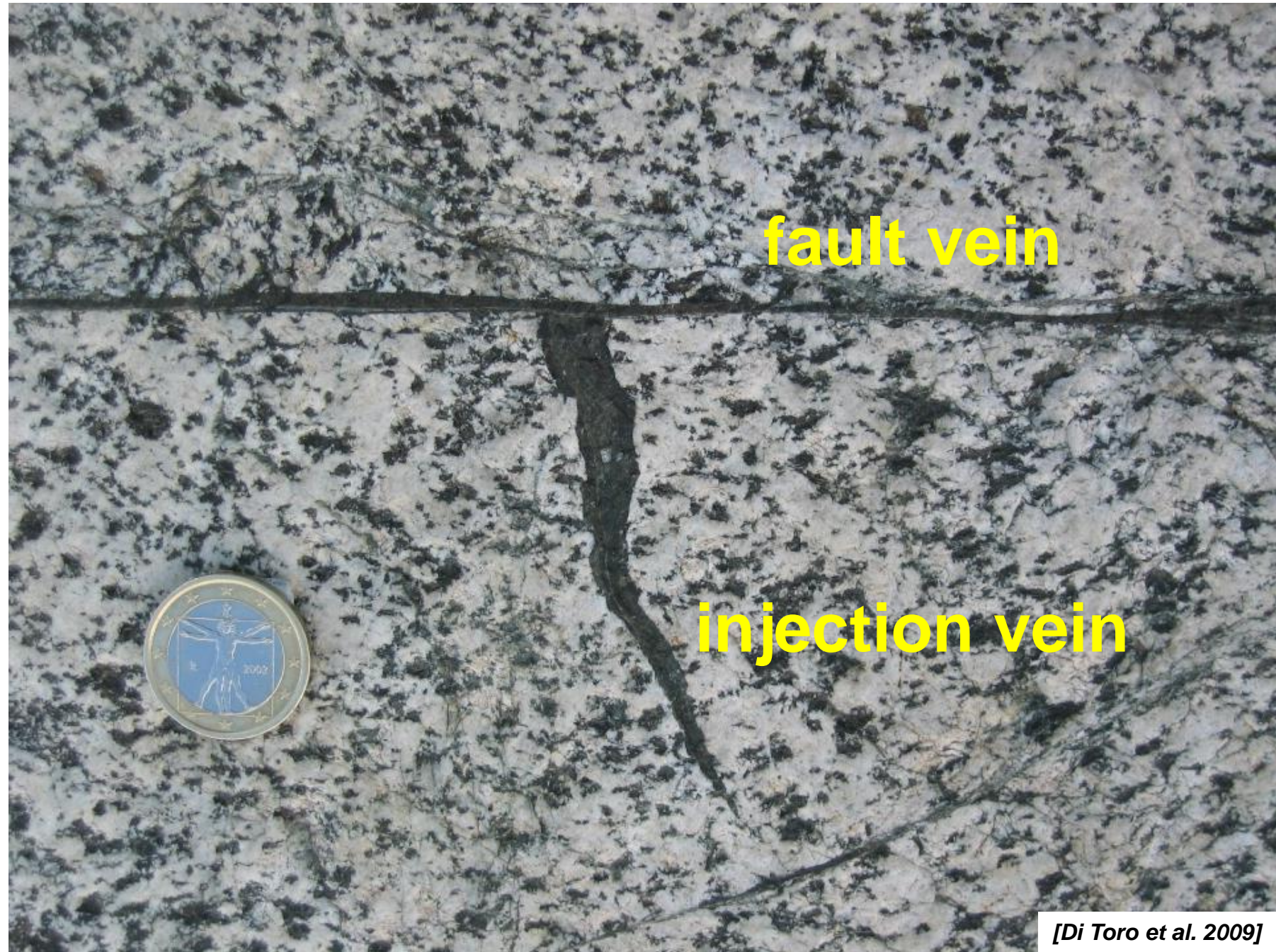
4. Discussion and Conclusions

5. References

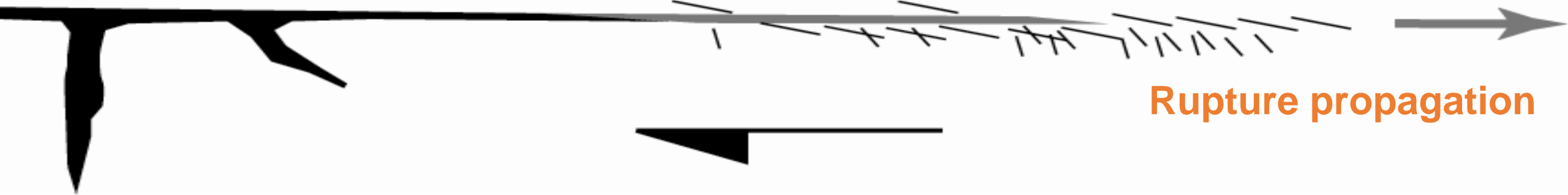
1. Motivations

Comminution and
frictional melting
along fault surface
during seismic slip

Pseudotachylyte from the
Gole Larghe Fault zone
(Adamello)



1 m/s on fault slip rate



3 km/s

Rupture propagation

Comminution & Frictional melting

[Modified from Swanson, 1992]

Pseudotachylyte
(Seismic glass)



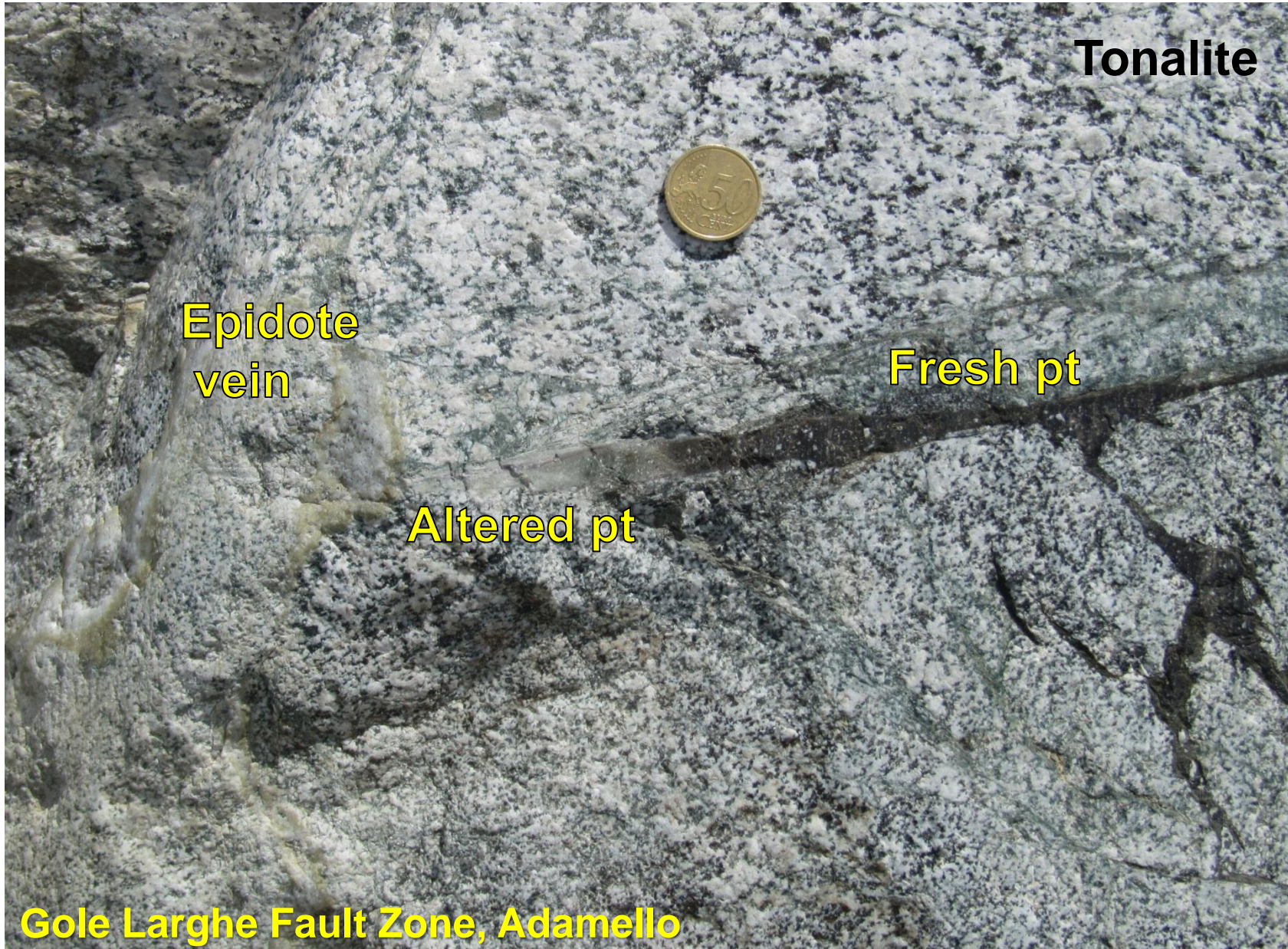
$$\Delta T \propto \mu \sigma_n V$$

ΔT up to $\sim 1500^\circ\text{C}$

Host rock: Tonalite

Pseudotachylytes are quite rare in the geological record: but are they rarely generated or are they only rarely preserved?

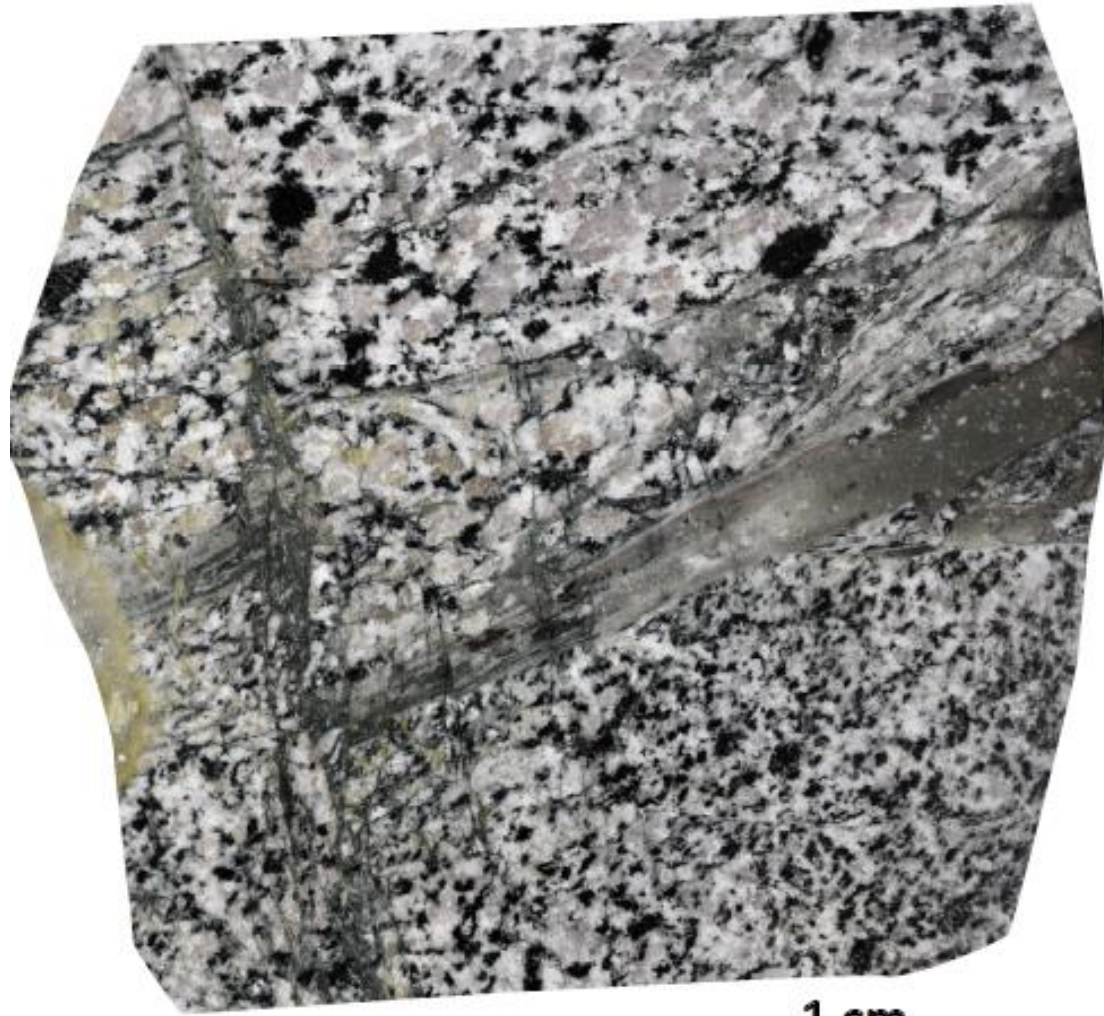
[Kirkpatrick & Rowe, 2013]



Alteration of these pseudotachylytes occurred at

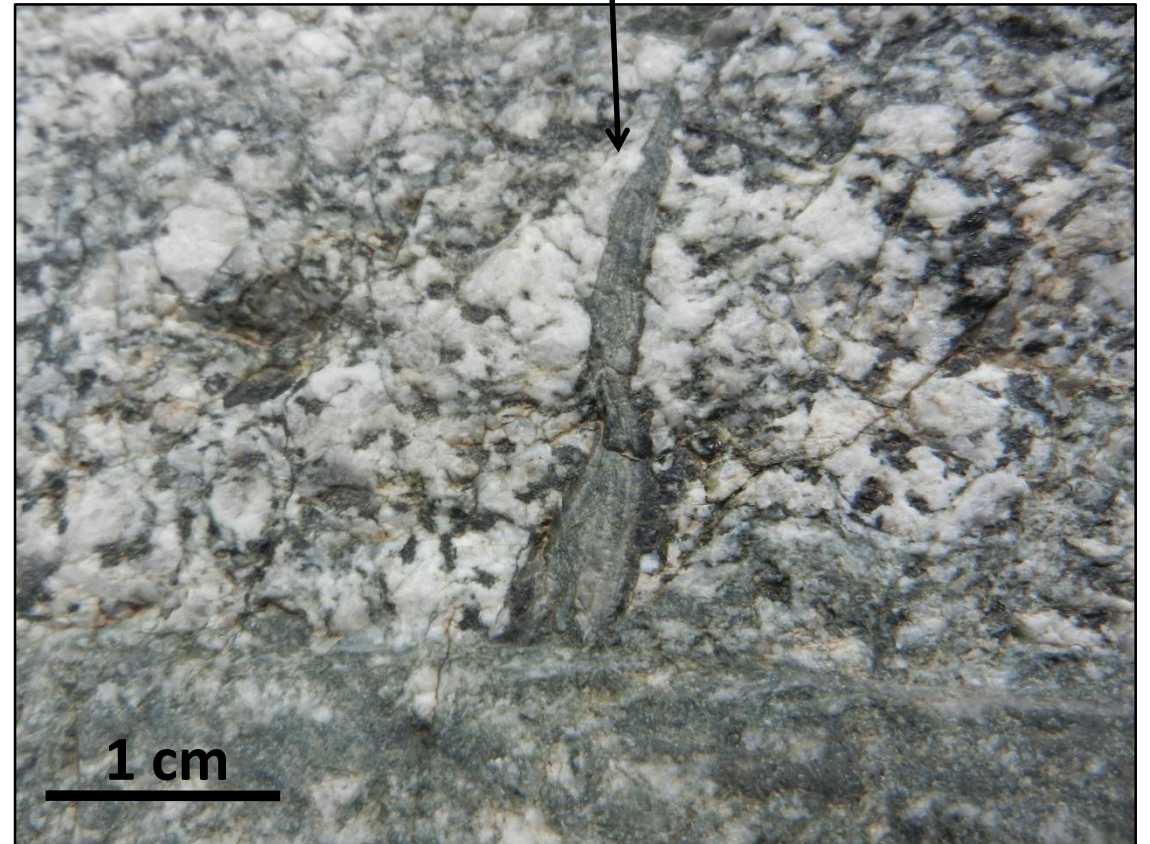
$T = 250^{\circ}\text{C}$

$P_c = 250 \text{ MPa}$

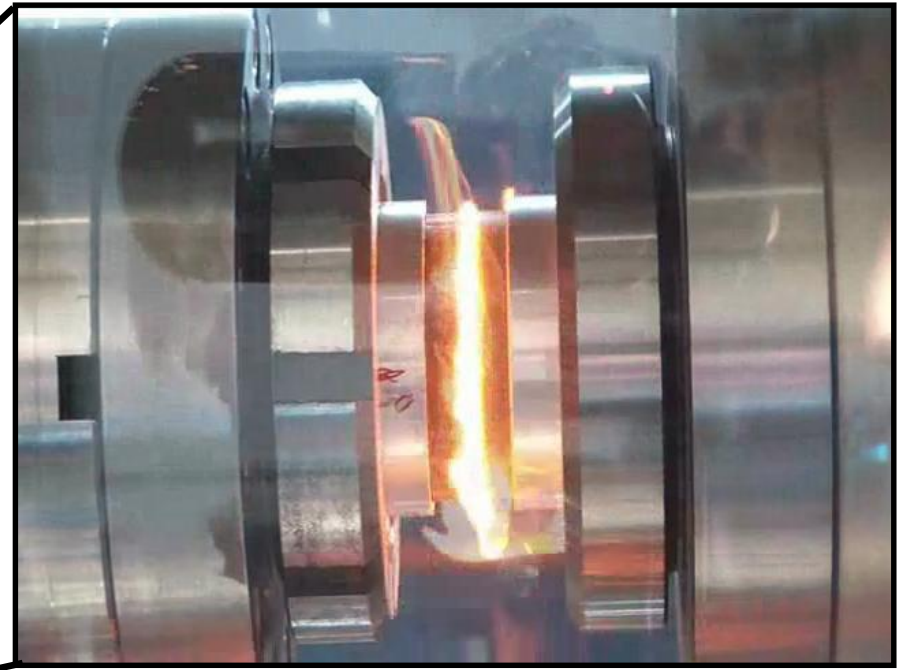
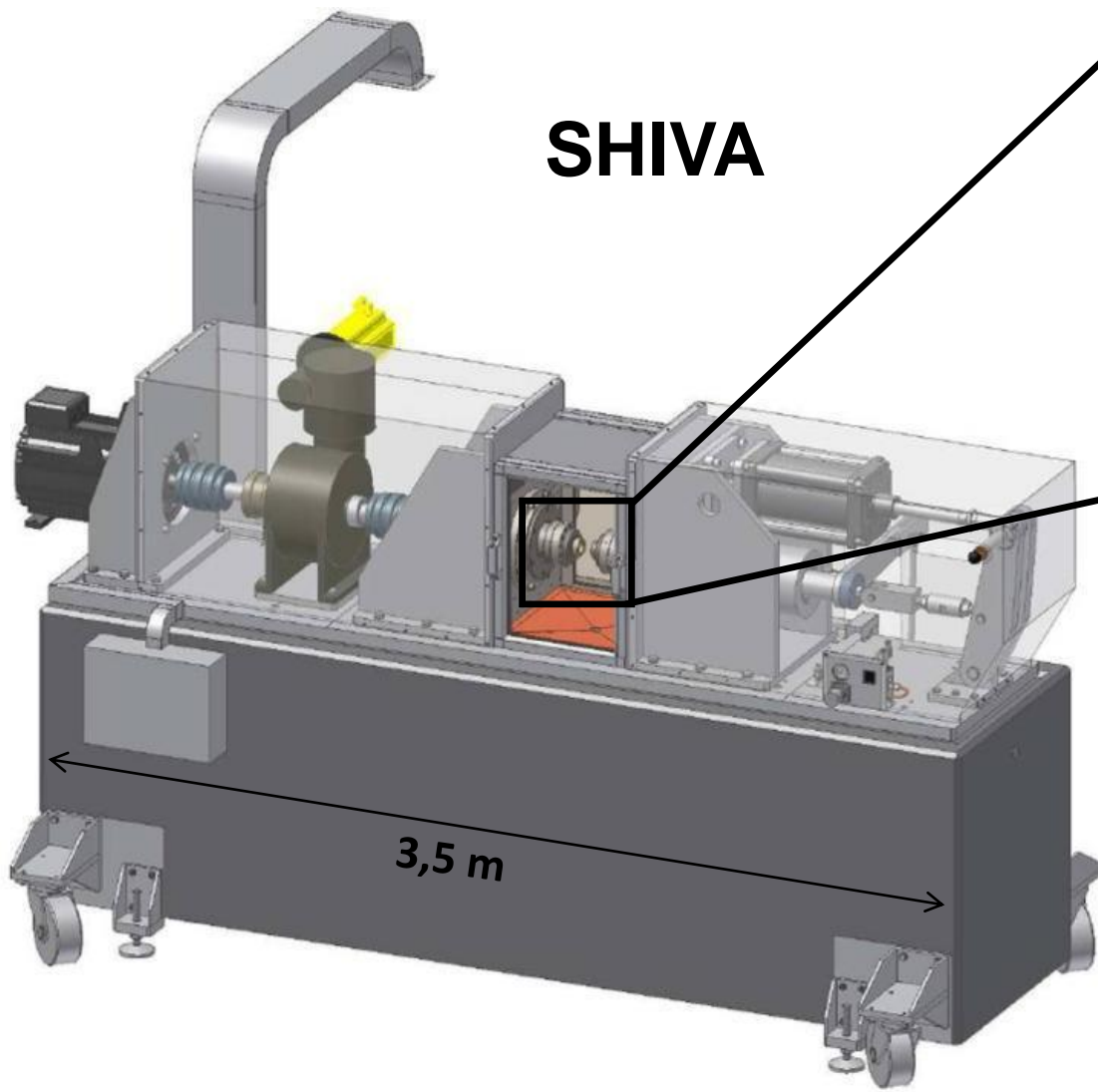


Natural pseudotachylyte with incipient alteration
(the left termination of the vein is foding into
greenish fault rock)

Natural altered pseudotachylytes



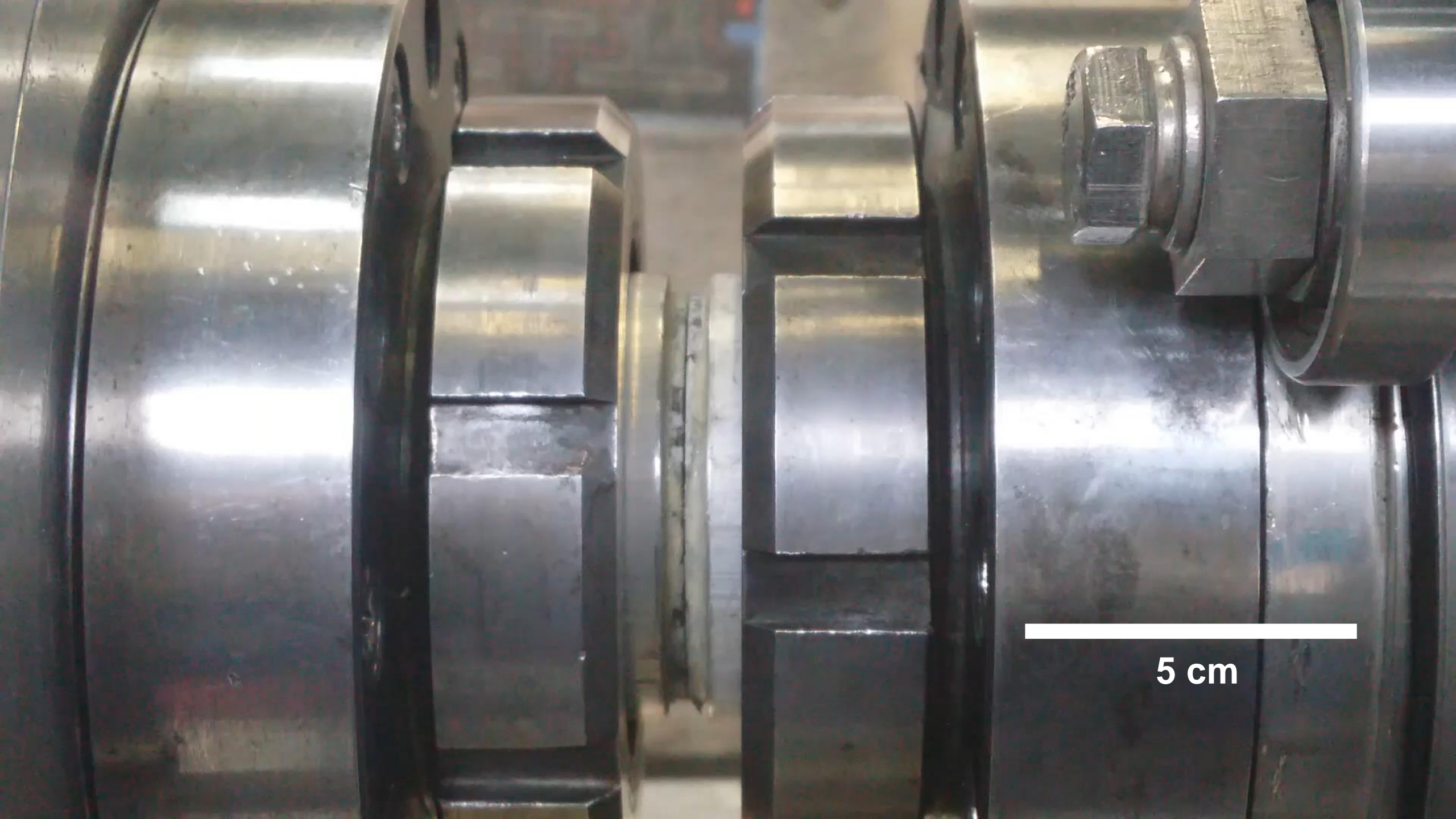
2. Methods: artificial pseudotachylytes



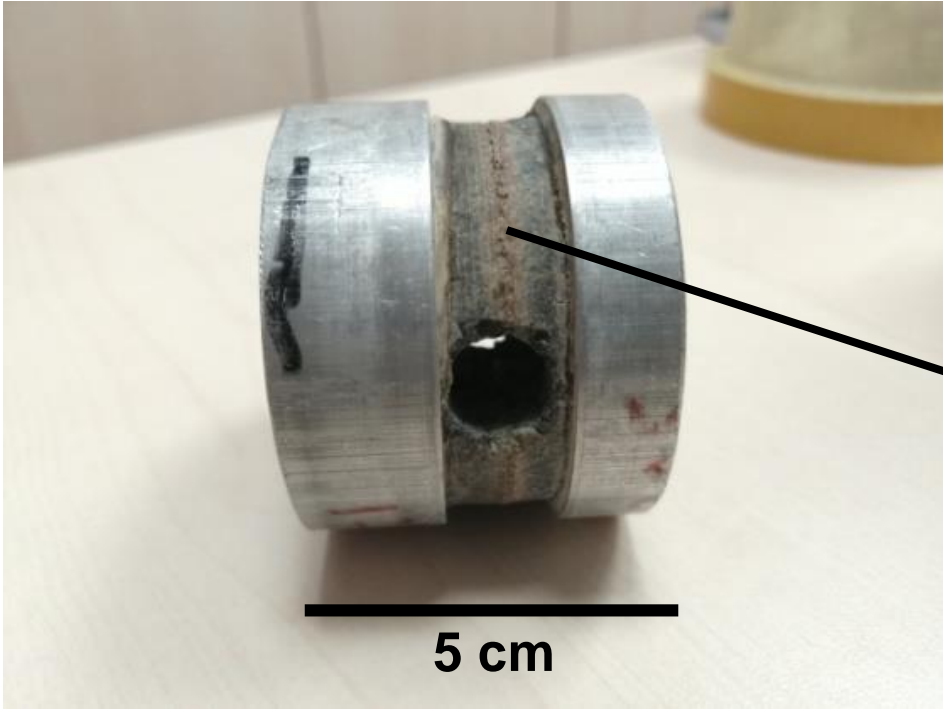
Pseudotachylytes were produced under vacuum by sliding at seismic slip rates (> 1 m/s) solid rock cylinders of tonalite (Plg + Qtz + Bt) using the rotary shear apparatus **SHIVA** at INGV-Rome



[Di Toro et al., 2010]

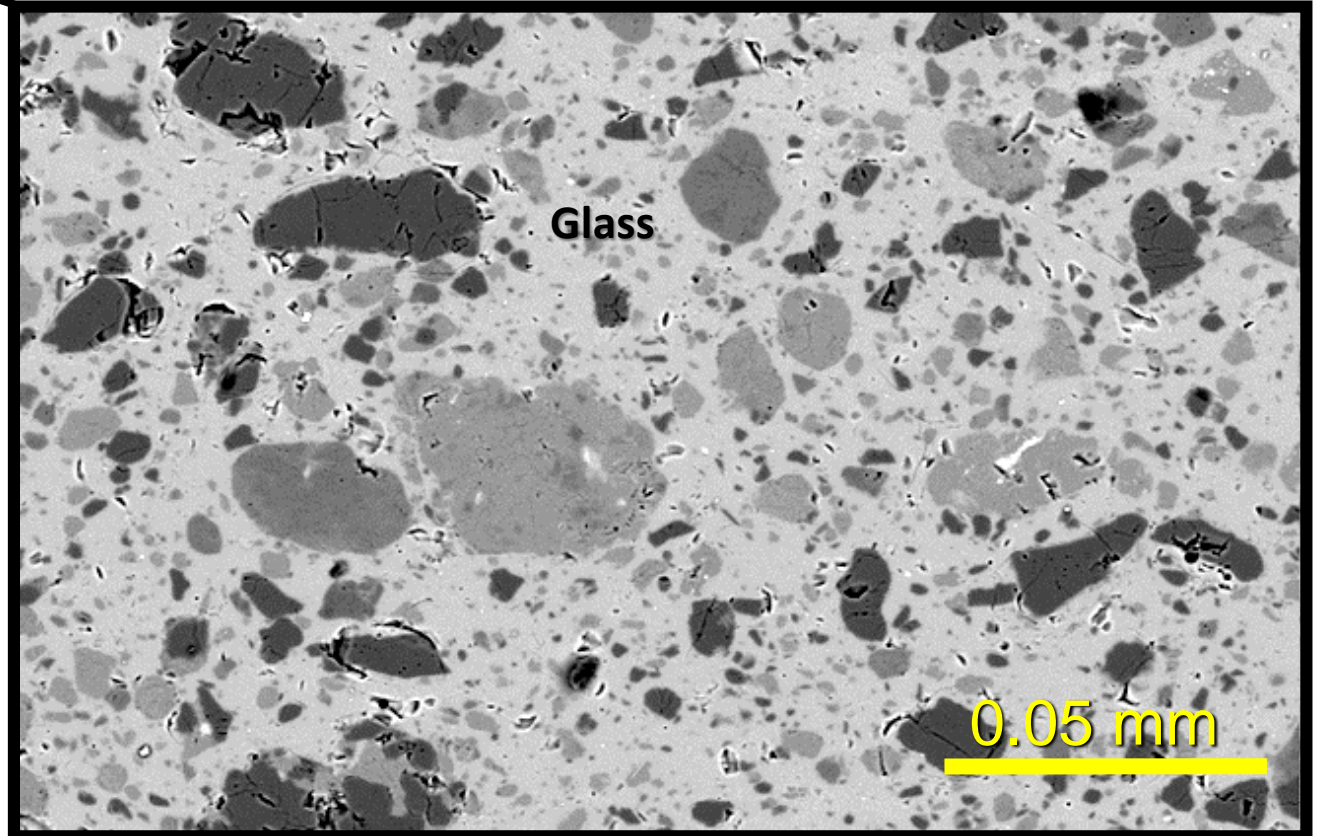


5 cm

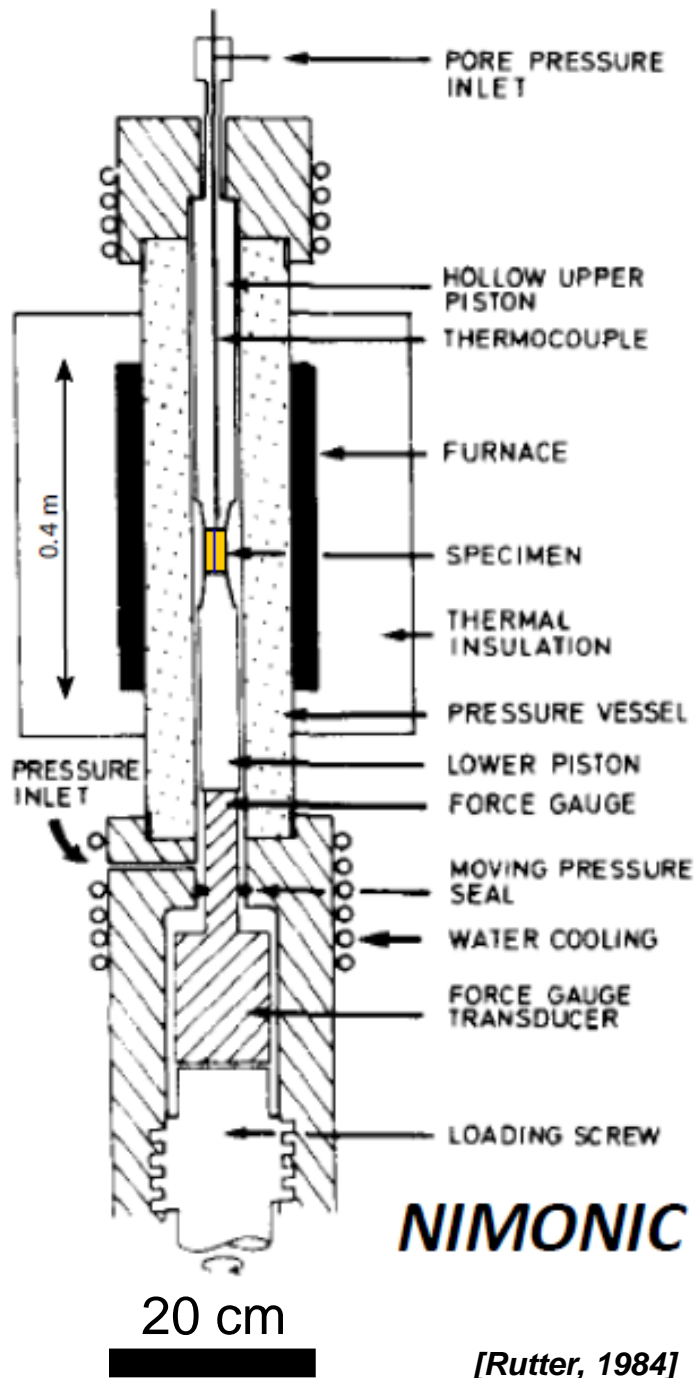


Samples were welded by the glass at the end of the experiment with SHIVA

We cored cylindrical specimens



SEM image



[Rutter, 1984]

Hydrothermal alteration test: representative (P and T) of the nature condition

Experimental conditions:

- $P_c = P_{H_2O} = 150 \text{ MPa}$
- $T = 350^\circ\text{C}$
- Time (days) = 35

Others methods

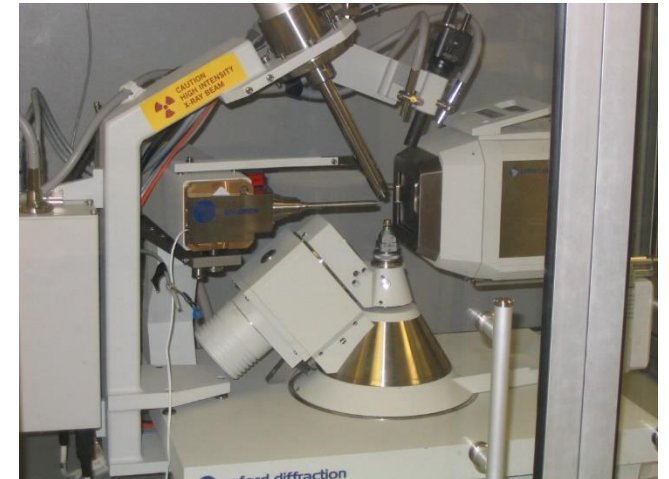
- FE-SEM (EDS analyses): microstructures



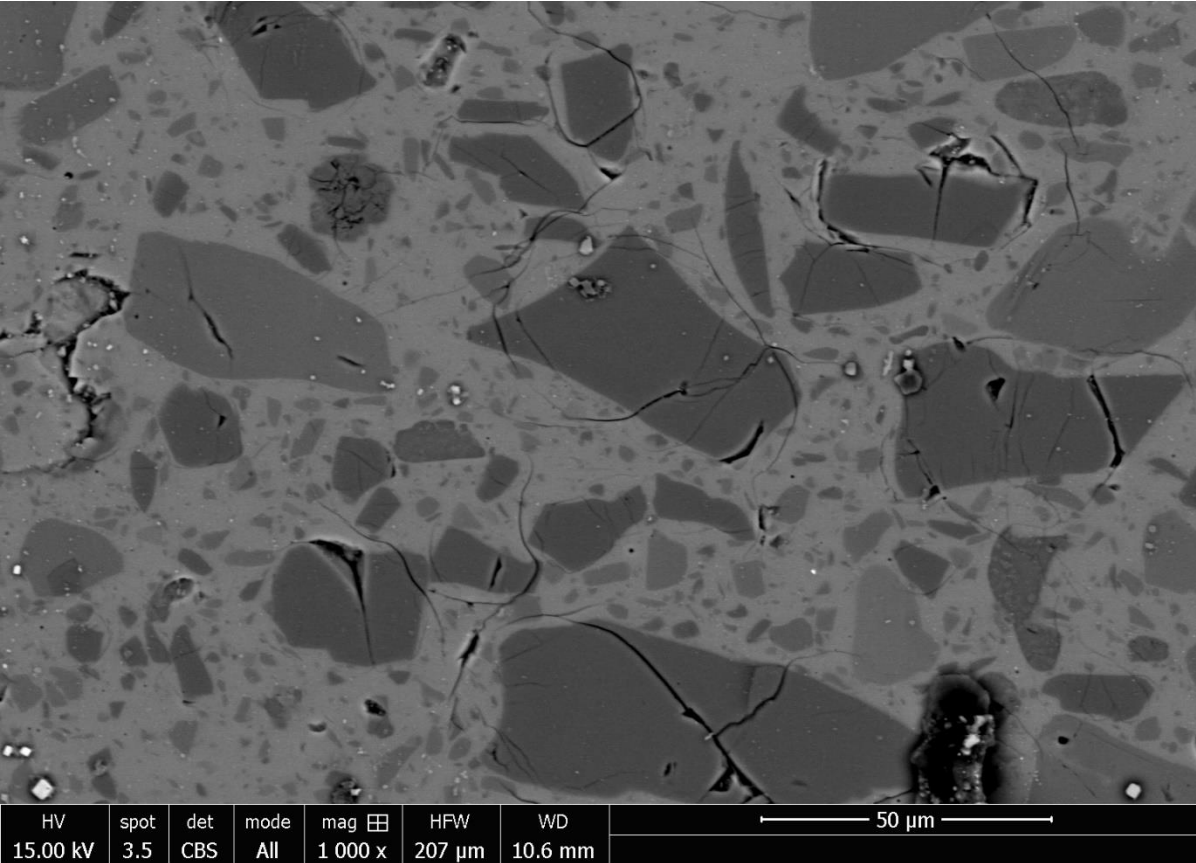
- Micro-Raman: mineralogy



- X-rays microdiffraction: high-resolution mineralogy

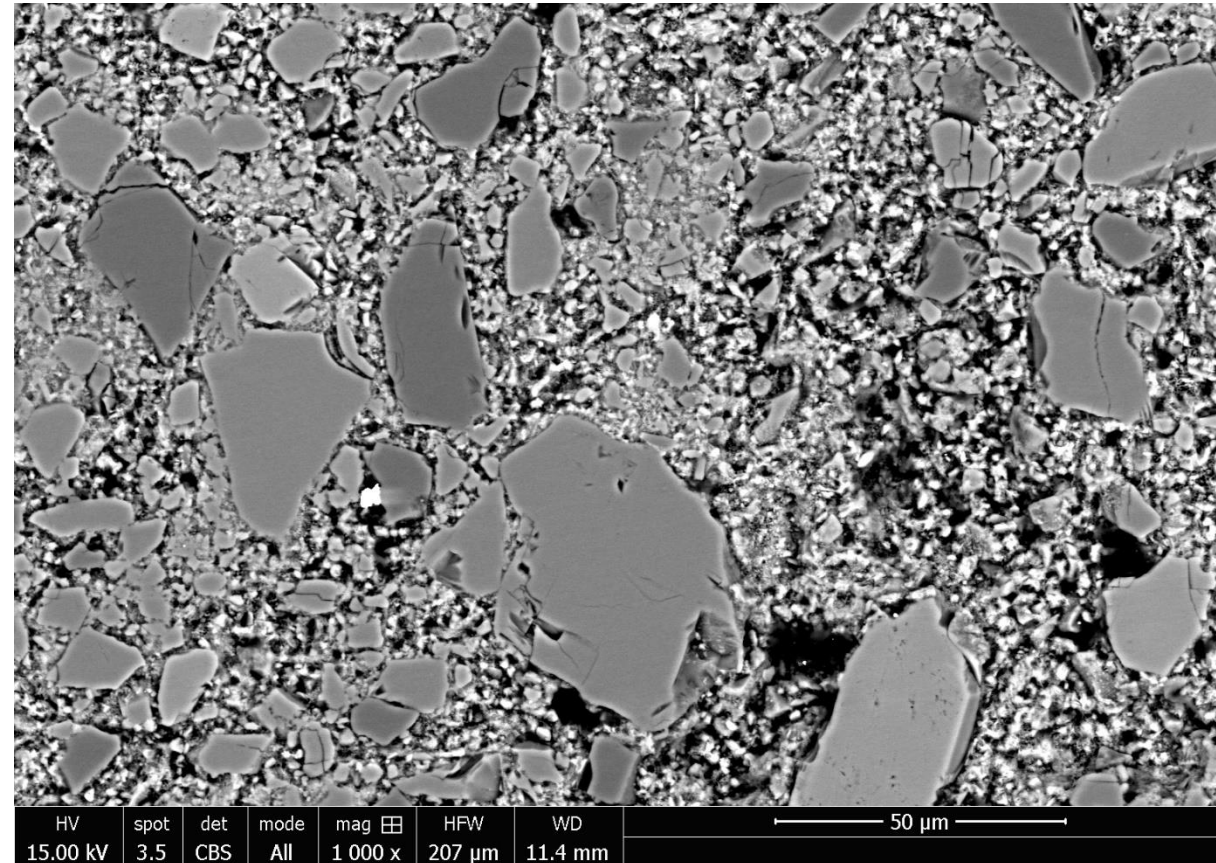


3. Artificial pseudotachylytes



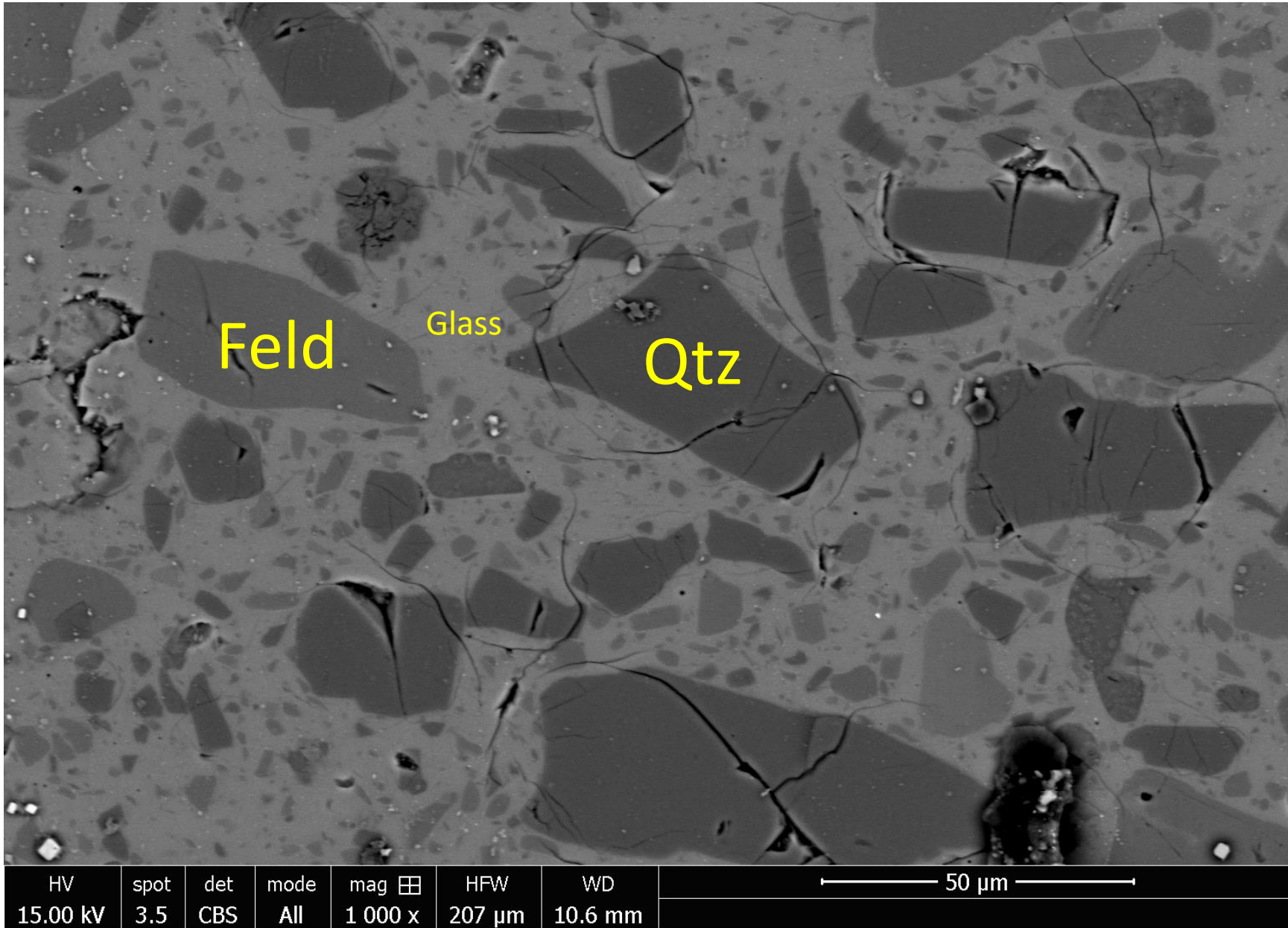
Fresh pseudotachylyte

➔
Hydrothermal alteration



Altered pseudotachylyte

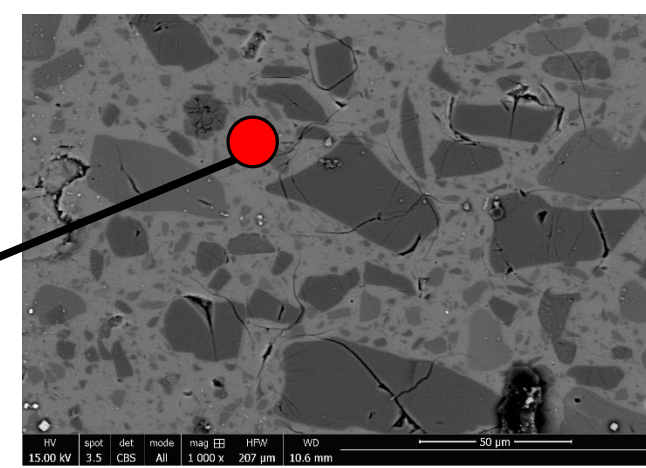
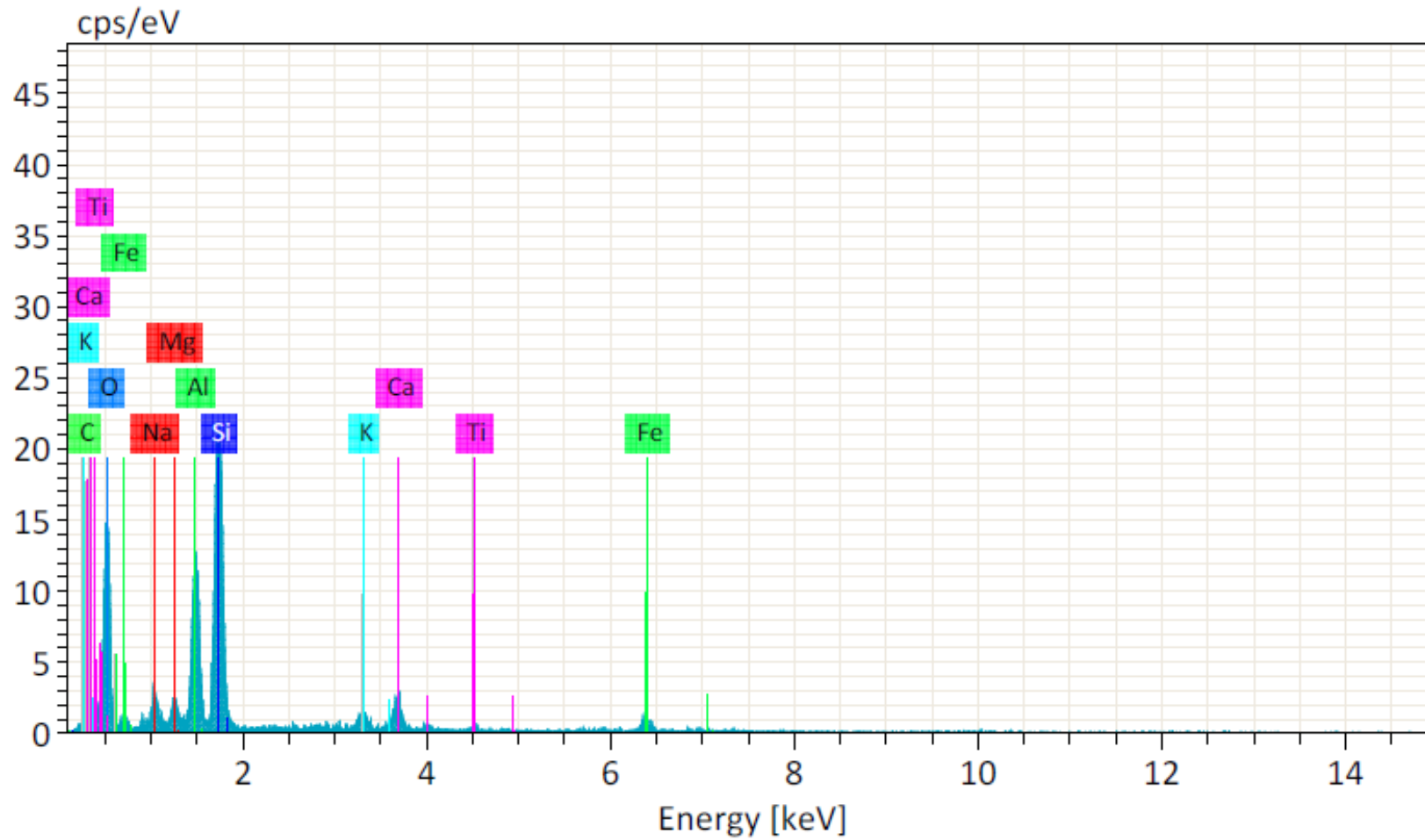
3.1 Fresh pseudotachylytes



Matrix

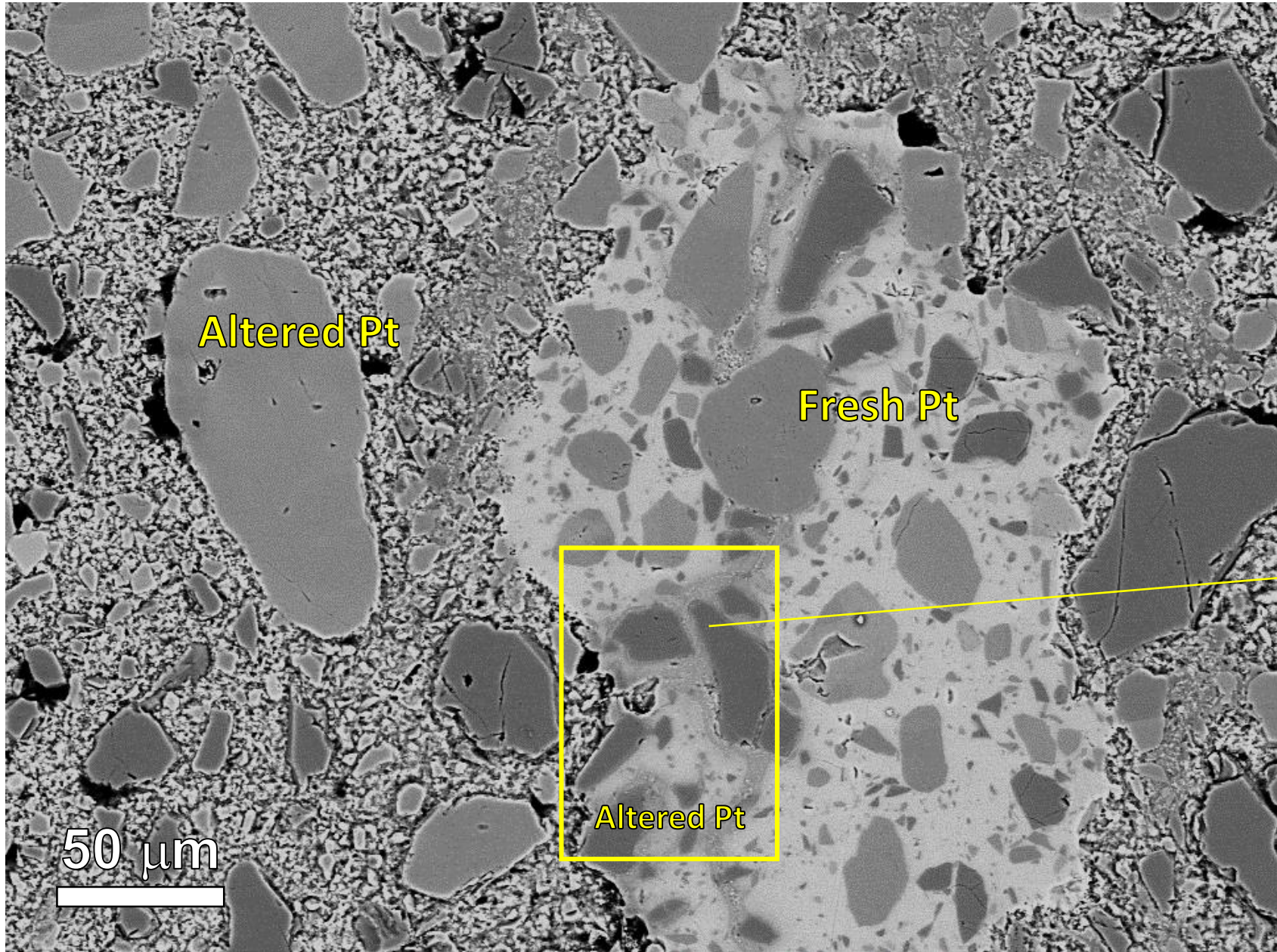
- Glassy
- No porosity

EDS analysis – glass-rich matrix



Glass is K-rich due to selective melting of biotite from the host rock

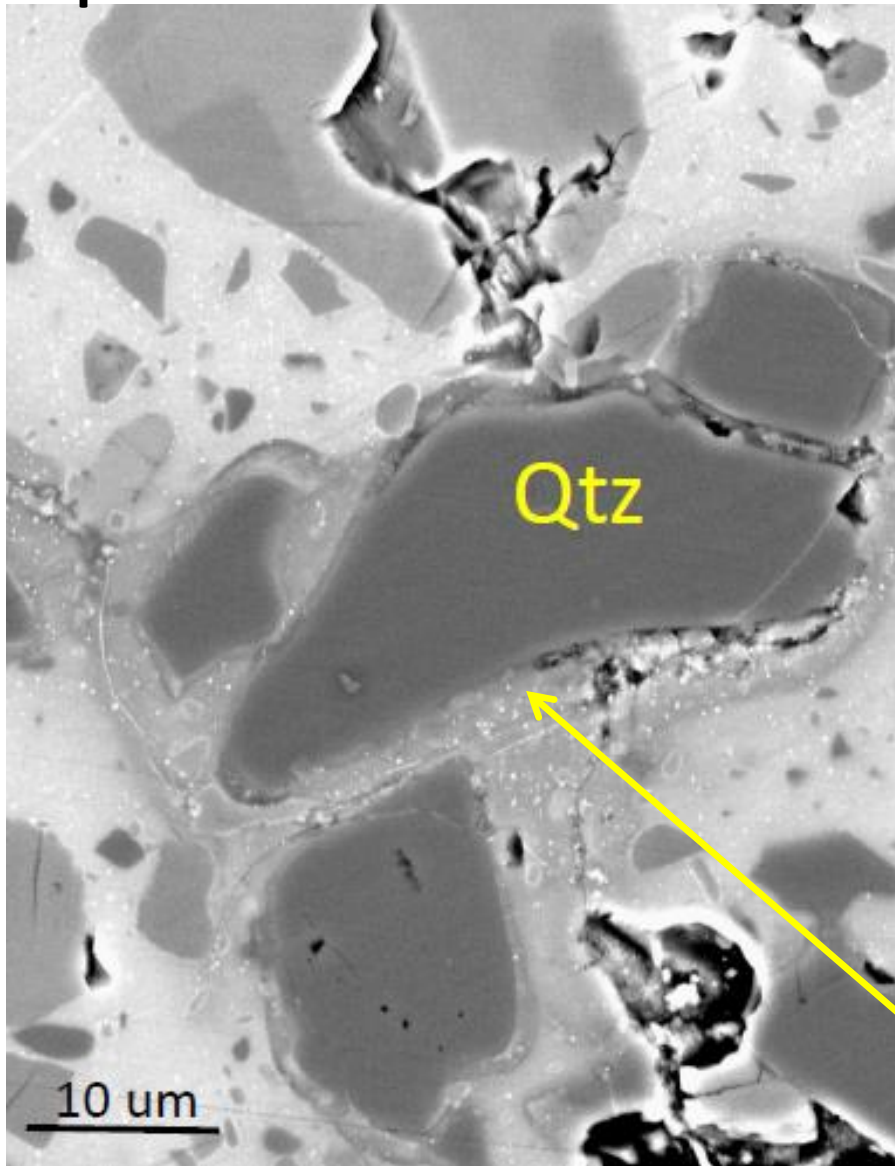
3.2 Altered pseudotachylytes



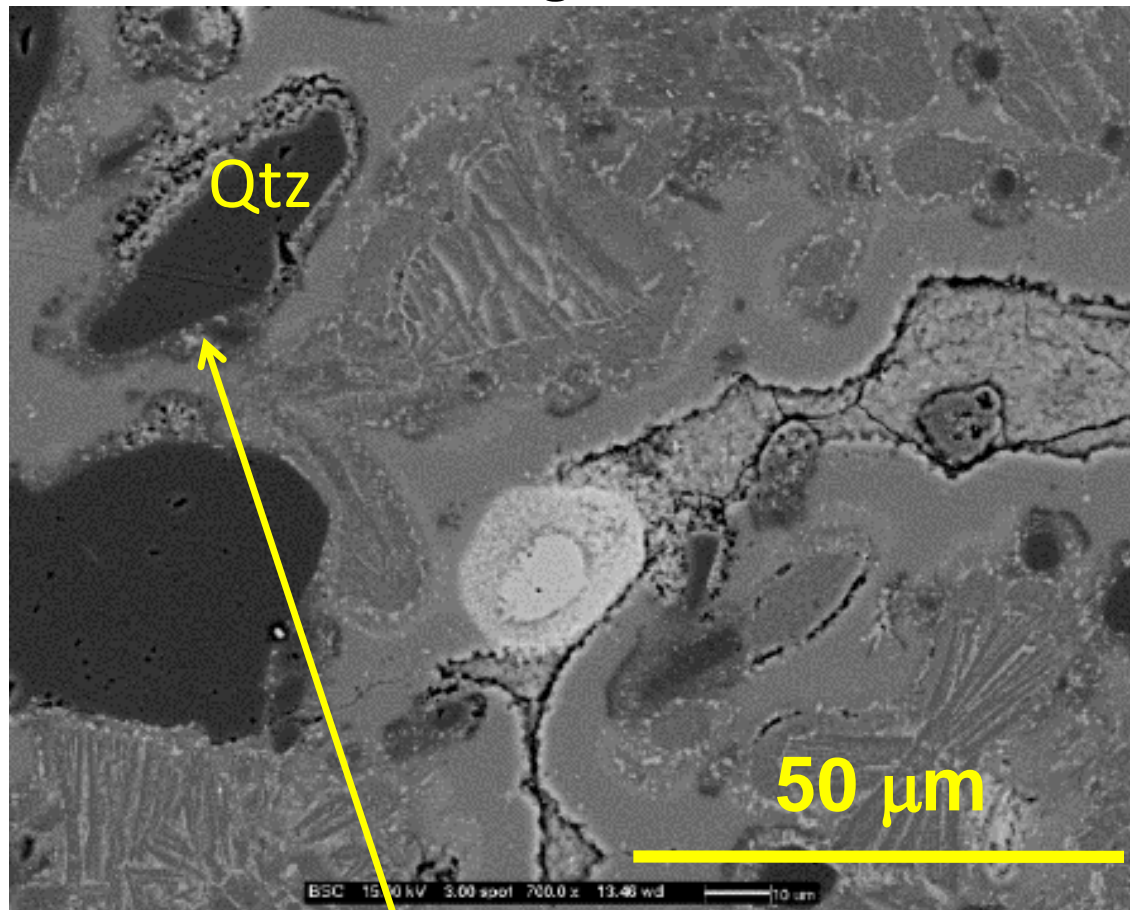
Qtz halo:
begin of alteration

Qtz halo

Experimental Pt

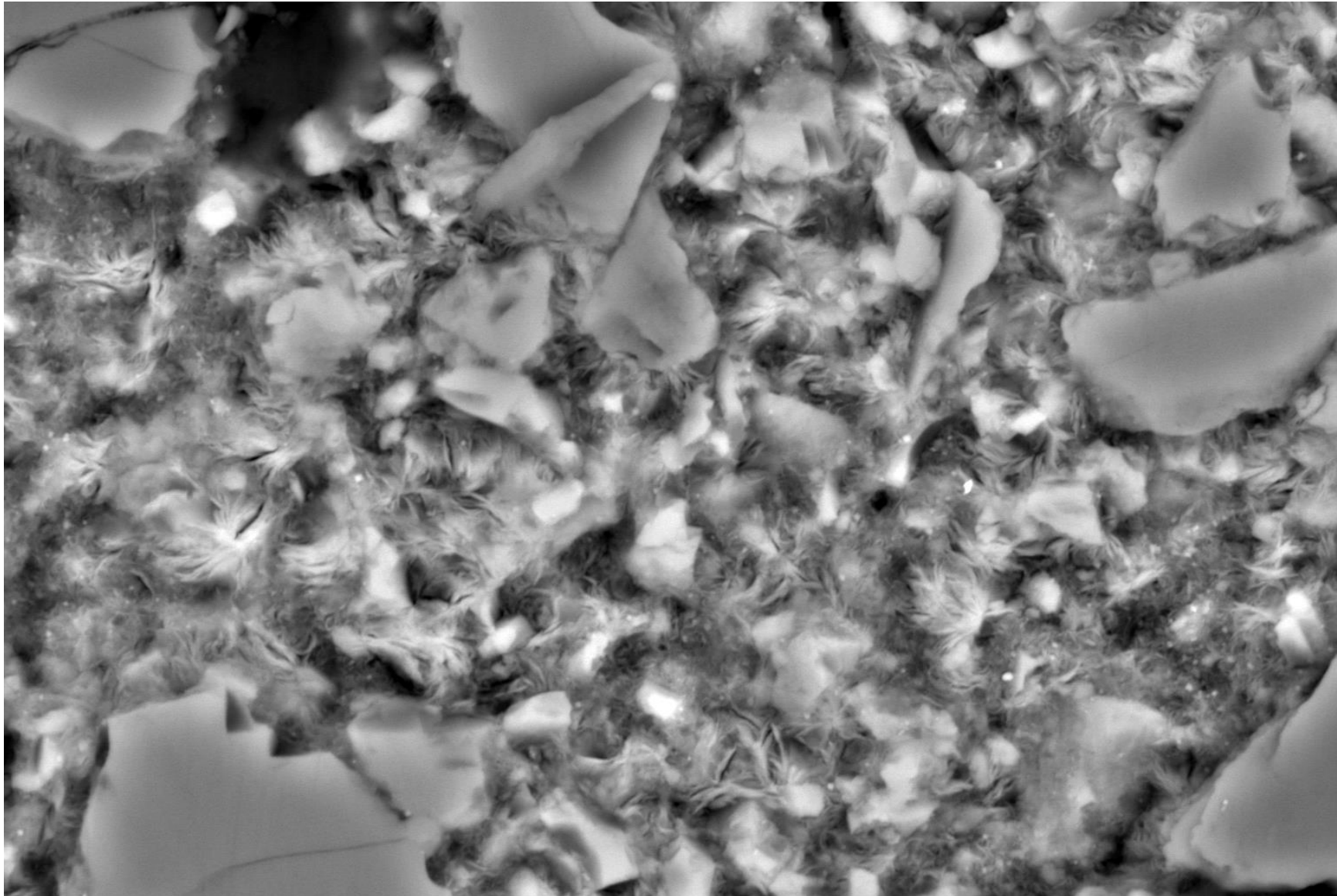


Natural Pt: Gole Larghe fault zone



Alteration halo around Qtz clasts

Formation of clays in experimentally altered pseudotachylyte

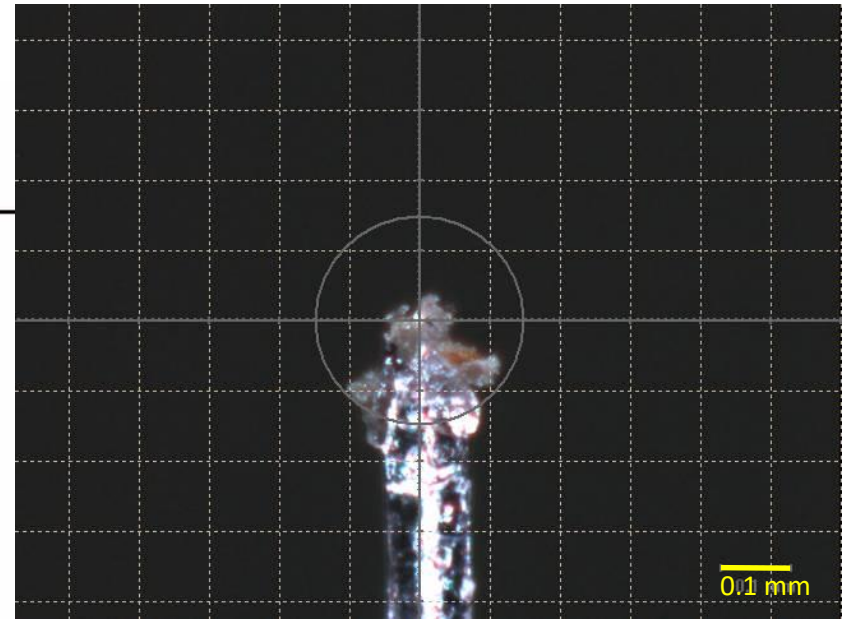
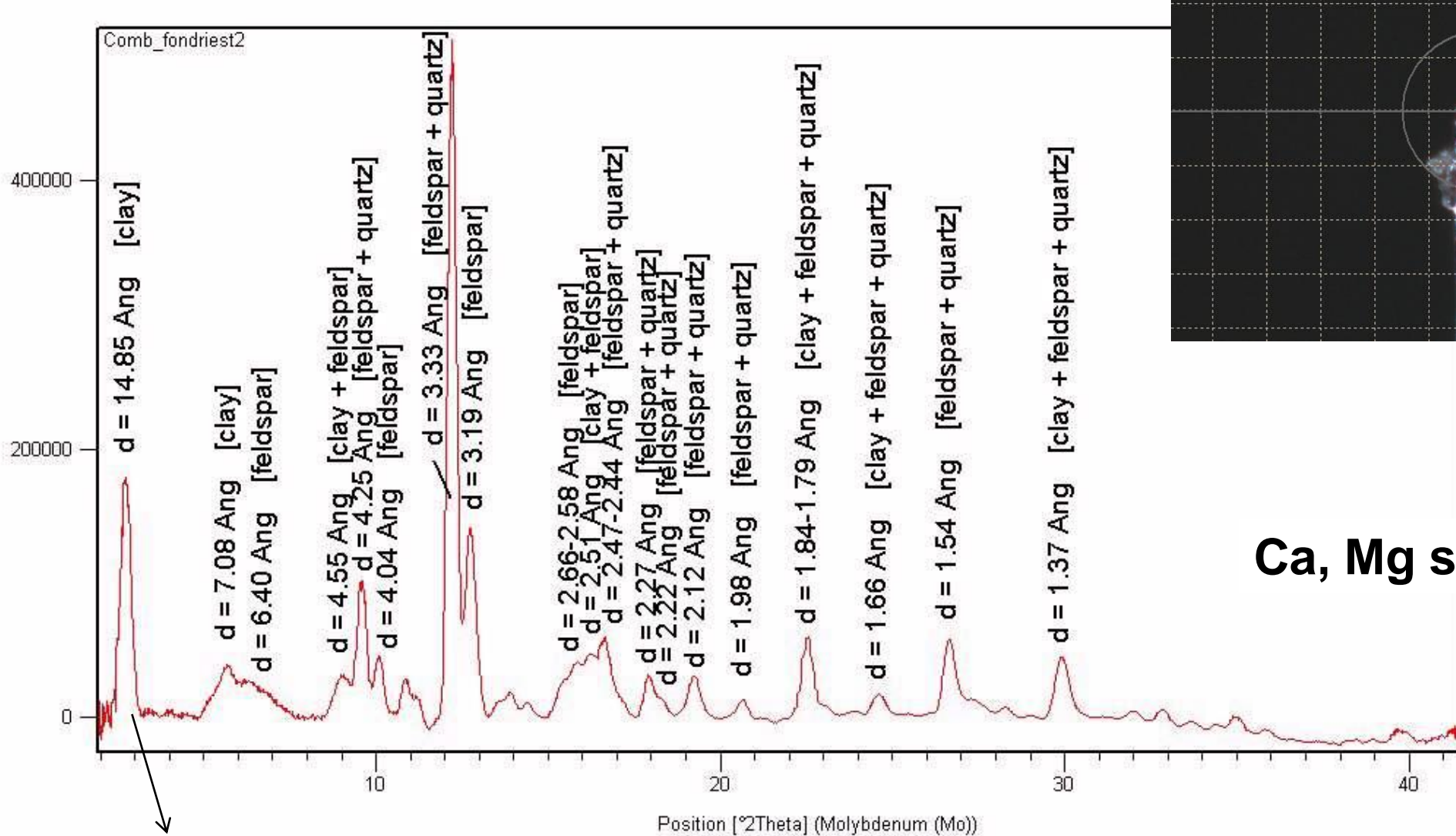


Matrix

- Acicular aggregates
 ————→ clays
- Devitrification
- > Porosity

HV	spot	det	mode	mag	HFV	WD	10 μm	
15.00 kV	3.5	CBS	All	5 000 x	41.4 μm	10.9 mm		

X-Rays microdiffraction



Ca, Mg smectite clay

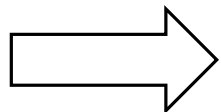
No diffraction spot but continuous ring

[Data produced by Fabrizio Nestola]

4. Conclusions

Pseudotachylytes are quite rare in the geological record: but are they rarely generated or are they only rarely preserved?

- Alterations of natural and artificial pseudotachylytes are similar (for example qtz halo)
- Glassy matrix (fresh PT) → Cryptocrystalline matrix (clays formation)
- The alteration in artificial PT begin around qtz clasts → halo of diffusion
- The morphology of the clasts changes (but will be seen more in detail in the next thesis)

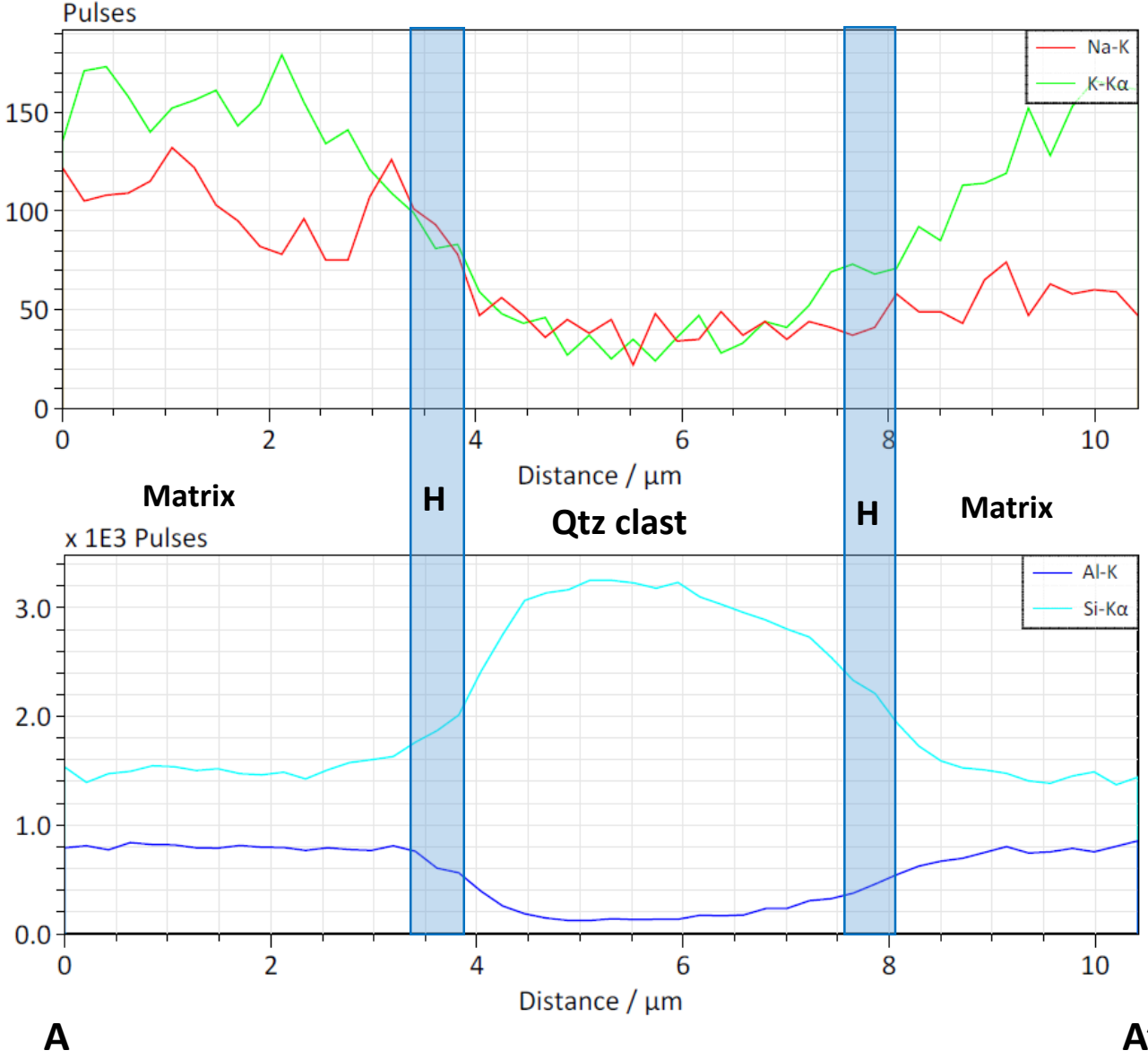
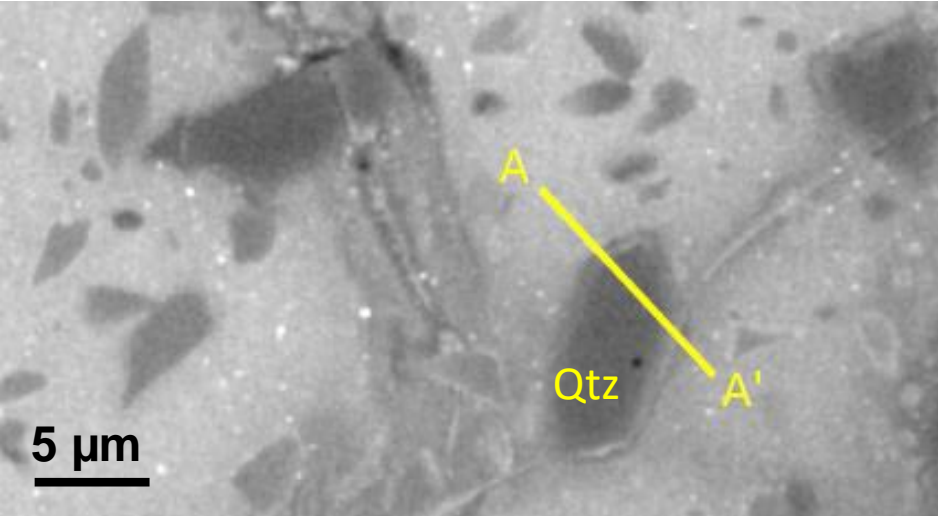


The alteration of PT is very short (day to month)

References

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- Fondriest M., Mecklenburgh J., Passelegue F.X., Artioli G., Nestola F., Spagnuolo E., Di Toro G., 2019. *Pseudotachylytes alteration and their loss from the geological record*. Abstract EGU2019 European Geoscience Union General Assembly, Vienna April 2019.
- Rutter, E.H. et al. (1984), Experimental ‘syntectonic’ hydration of basalt, *J. Struct. Geol.*, 7(2), 251–266.
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- Sibson, R.H. (1975), Generation of Pseudotachylyte by Ancient Seismic Faulting, *Geophys. J. Int.*, 43(3), 775–794.
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Halo profile analysis



[Fondriest et al. 2019, EGU]