PERMEABILITY EVOLUTION OF PSEUDOTACHYLYTES DURING HYDROTHERMAL ALTERATION EXPERIMENTS - PRELIMINARY RESULTS

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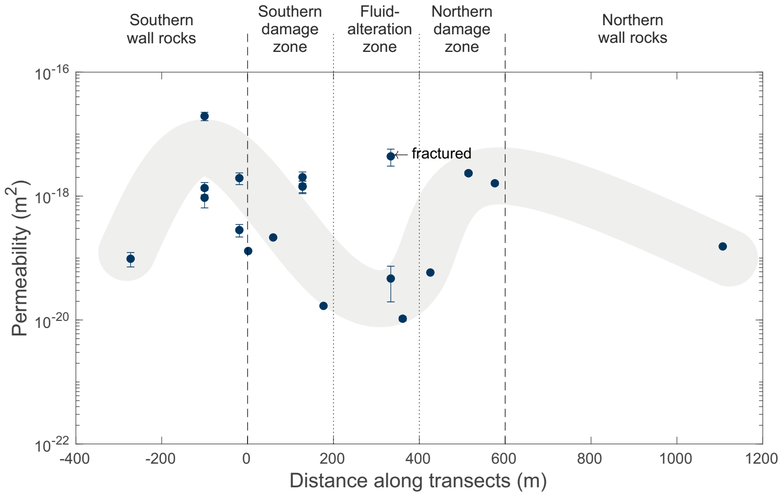
Motivation

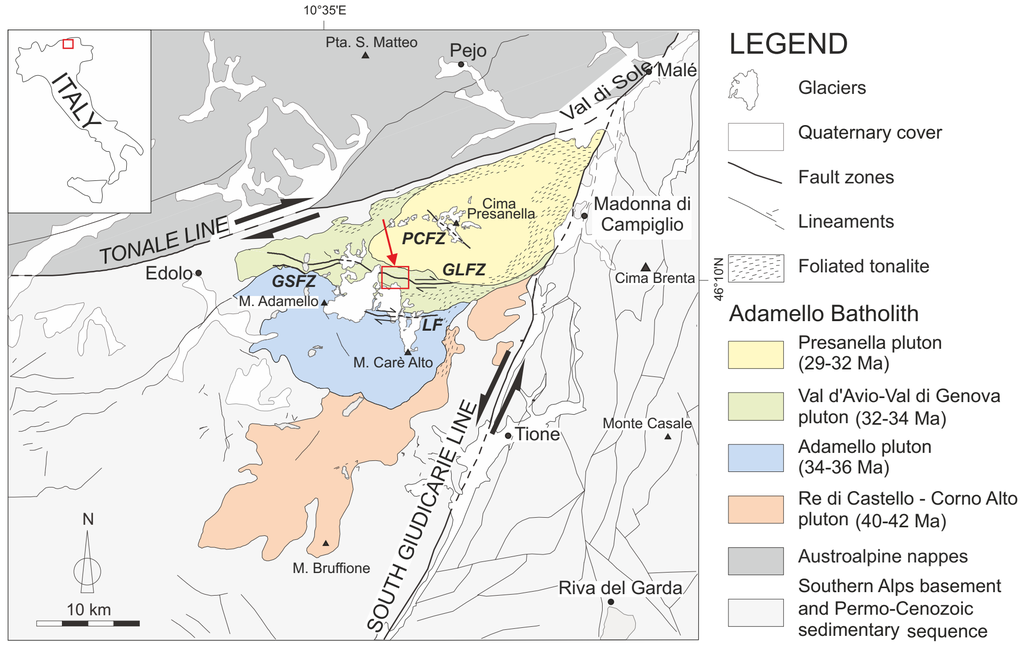
- The apparently low abundance of pseudotachylytes in field outcrops of fault zones may be due to their alteration and hence destruction of characteristic microstructures
- Presumably, the potential for hydrothermal alteration of rocks is largely controlled by the availability of water that in turn depends on the rocks' permeability. The permeability of pseudotachylytes, which generally exhibit a fine-grained matrix, is expected to be low relative to their host rock, such that infiltration by fluids should be minimal.
- Here we show preliminary results of oscillatory pore-pressure experiments at temperatures that prevail at the depths at which pseudotachylytes formed in nature, on pseudotachylyte samples from the Gole Larghe fault zone, Italian Southern Alps
- Additional microstructural analyses of naturally and experimentally altered pseudotachylytes will help to constrain the alteration processes and associated kinetics. Our results will contribute to answer the question how quickly pseudotachylytes are lost from the rock record.

Geological Setting: Gole Larghe fault zone, Italian Southern Alps

- Dextral strike-slip fault zone
- Tonalitic host rock
- Exhumed from 9-11 km depth (~300°C)
- ~600 m wide damage zone, consisting of strands of hydrothermally altered cataclasite (epidote, chlorite) and pseudotachylite-bearing faults
- The permeability of rocks within the Gole Larghe fault zones varies between $k \sim 10^{-18}$ m² and $k \sim 10^{-20}$ m² depending on intensity of microfracturing and degree of healing and sealing of fractures (Rempe et al., 2018).



Rempe et al., JGR, 2018



Rempe et al., 2018

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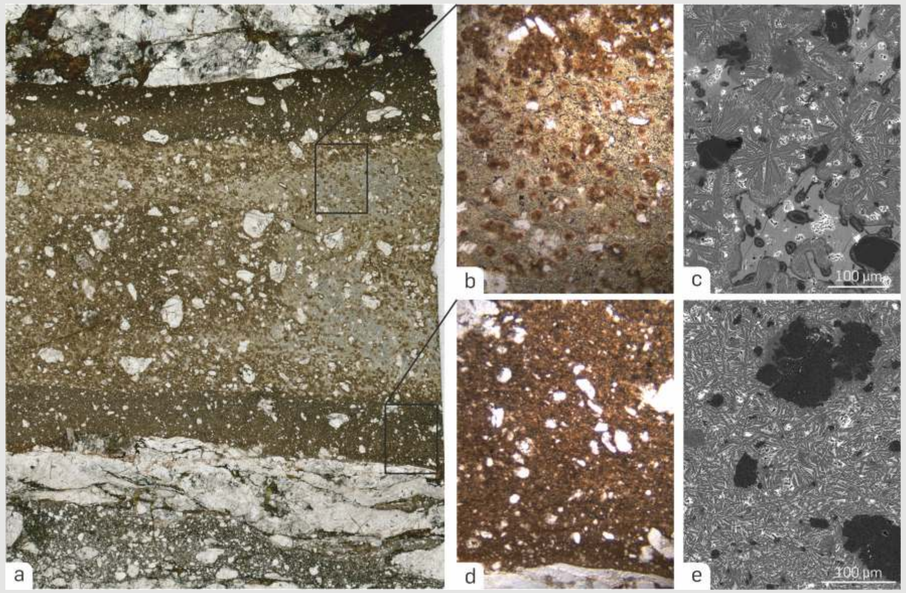
Appearance of „fresh“ pseudotachylytes



a) Thin section scan of pseudotachylyte vein, from which samples for permeability measurements were cored. b) and c) Optical micrograph of spherulitic domain. d) and e) Microlitic domain.

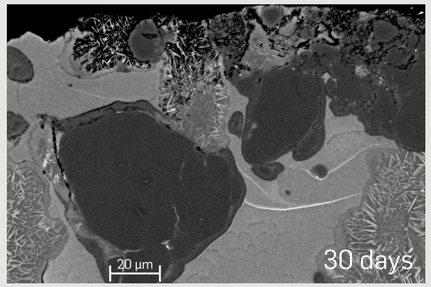
- Typical fault vein - injection vein geometry
- Fine-grained black matrix
- mm-sized quartz or plagioclase fragments
- No presence of glass reported

- Textural zoning likely due to varying cooling rate
- **Spherulitic domain**: plagioclase spherulites within i) crypto-crystalline matrix thought to derive from devitrified glass or ii) K-feldspar-rich matrix. Fractures within matrix.
- **Microlitic domain**: randomly-oriented plagioclase needles with interstitial biotite and a small amount of K-feldspar

Di Toro and Pennacchioni, 2004

Naturally altered pseudotachylytes

Experimentally altered pseudotachylytes



- Naturally altered pseudotachylytes are dark to light grey or greenish in color; fine-grained chilled margin is preferentially preserved/less altered
- Experimental alteration of natural pseudo-tachylyte samples in pressure autoclaves:
  - Pore fluid: distilled water, water-rock ratio: 20, temperature: 200 °C
  - Similar to natural examples, samples that were experimentally altered show macroscopic change in color from dark to light grey: What causes this change in color?
  - Surfaces of samples appear affected by alteration (dissolution of plagioclase spherulites and quartz clasts)

See also Fondriest et al., in review

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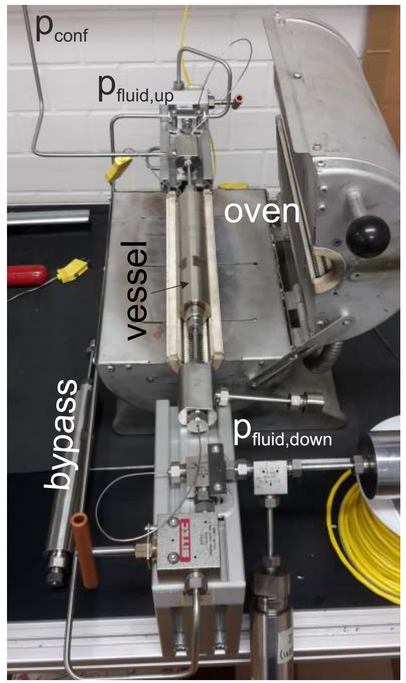
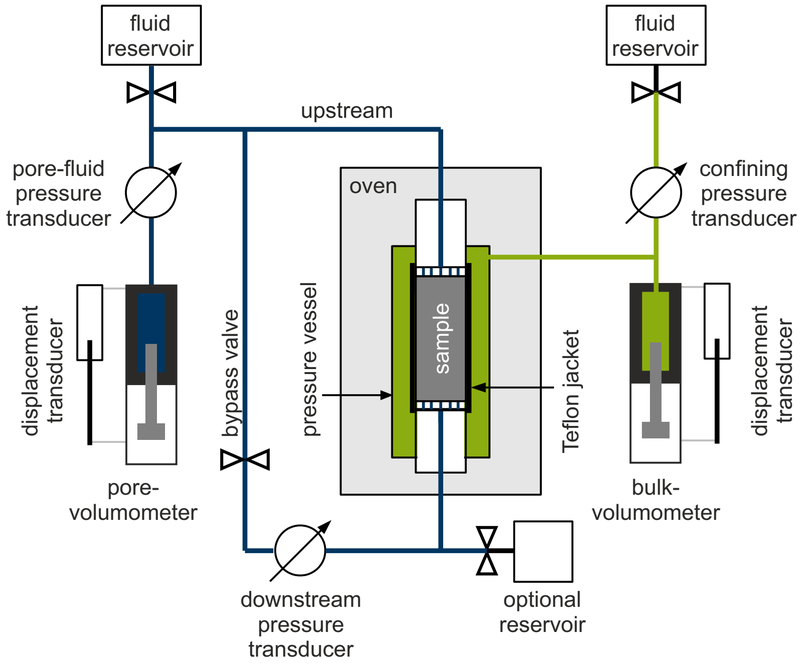
Permeability measurements: Methods

- Permeability measurements on cylindrical samples (d=10 mm) cored from „fresh“ pseudotachylyte fault veins within externally heated pressure chamber
- Oscillatory pore-pressure method (Kranz et al., 1990; Fischer, 1992) yields permeability, specific storage capacity and hydraulic diffusivity of the sample assuming a homogeneous, isotropic medium
- Pore fluid: distilled water



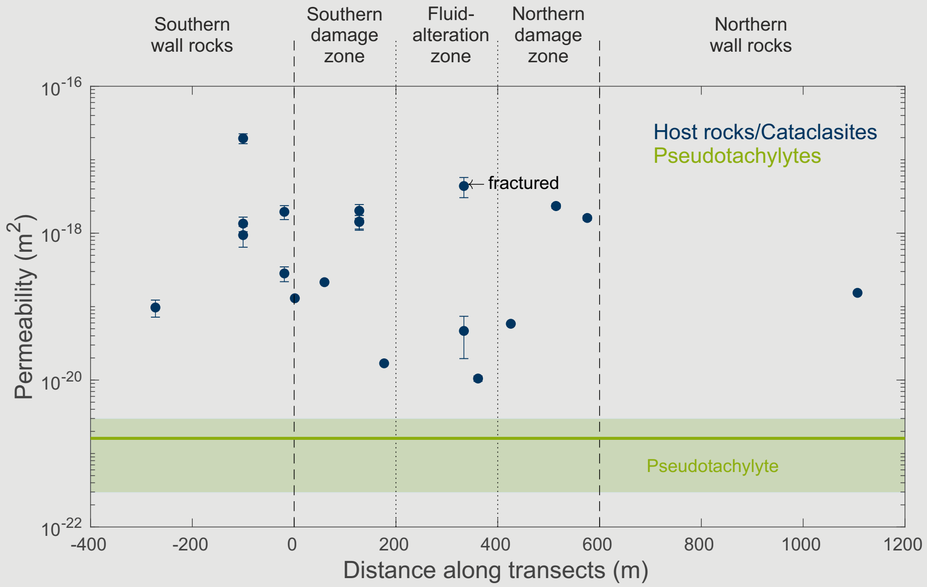
Photograph of cylindrical pressure chamber inside oven (with open lid).



Experimental set-up used for the permeability measurements. Servo-controlled confining- and pore-pressure systems in green and blue, respectively. Not to scale.

First results

- Permeability determined for three „fresh“ pseudotachylyte samples was in the order of $k \sim 10^{-21}$ m²
- Hydrothermal alteration of one sample at 220 °C for (as of now) 6 days did not yield a significant permeability change



- Permeability of pseudotachylytes is significantly lower than permeability of host rocks and cataclasites from the Gole Larghe fault zone
  - ➢ Pseudotachylytes are likely not subjected to infiltration by fluids and therefore do not experience strong alteration
  - ➢ However, fractures within pseudotachylyte veins may act as pathways for fluids and lead to localized alteration

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Conclusions & Outlook

- As permeability of pseudotachylytes from the Gole Larghe fault zone is significantly lower than permeability of host rocks and cataclasites from the same fault zone, pseudotachylytes do not experience strong hydrothermal alteration
- Thus, significant alteration may require intermittent brittle deformation introducing fractures

- In fact, in the Gole Larghe fault zone, field evidence (e.g., offset pseudotachylytes) shows that brittle deformation postdated pseudotachylyte generation

- In the future, samples will be hydrothermally altered in permeability set-up and in pressure autoclaves for durations up to three months
- We will test the altered samples for changes in permeability, microstructural characteristics and chemical/mineraological composition to obtain more information on alteration processes and associated kinetics

References

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