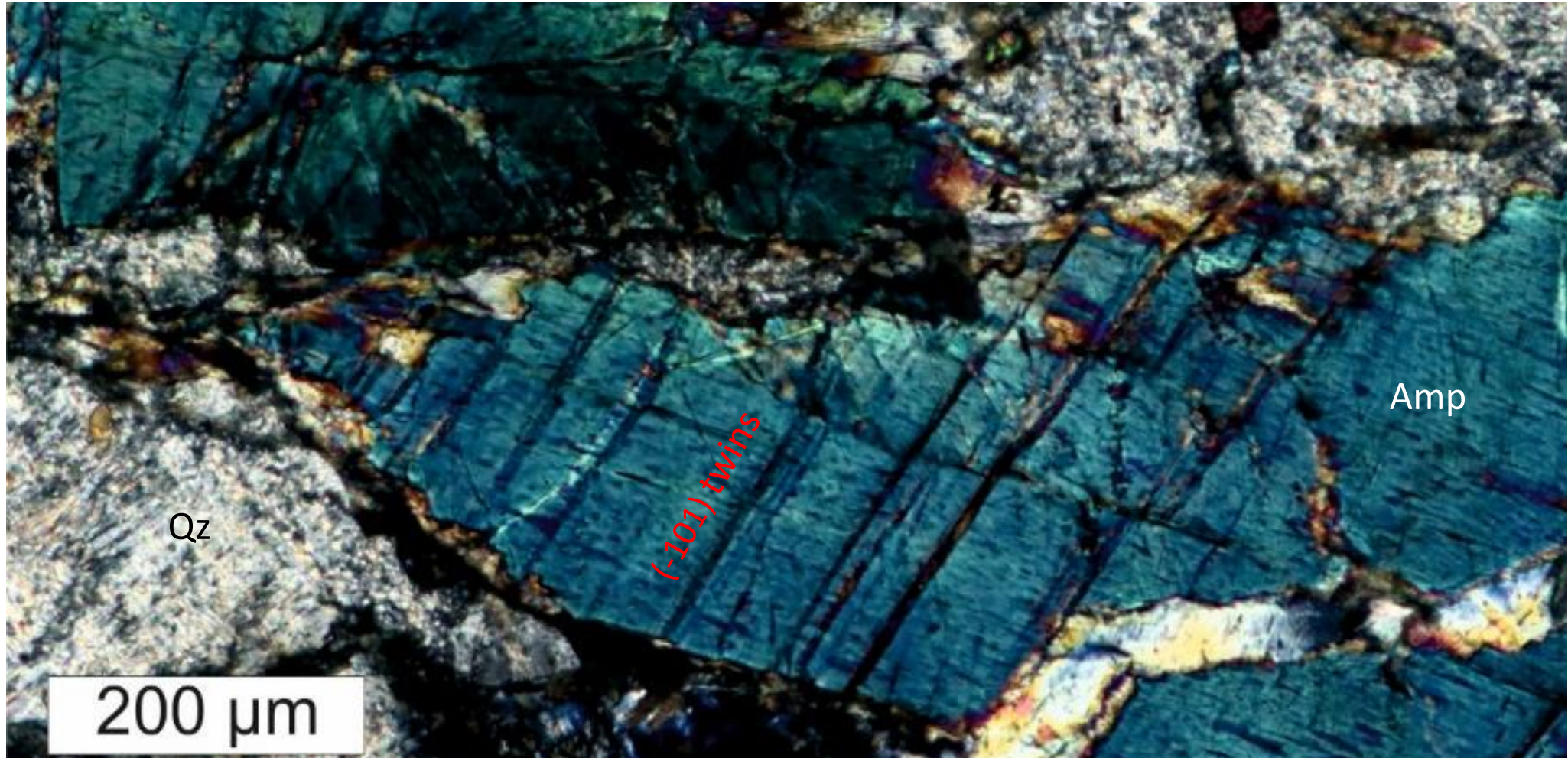


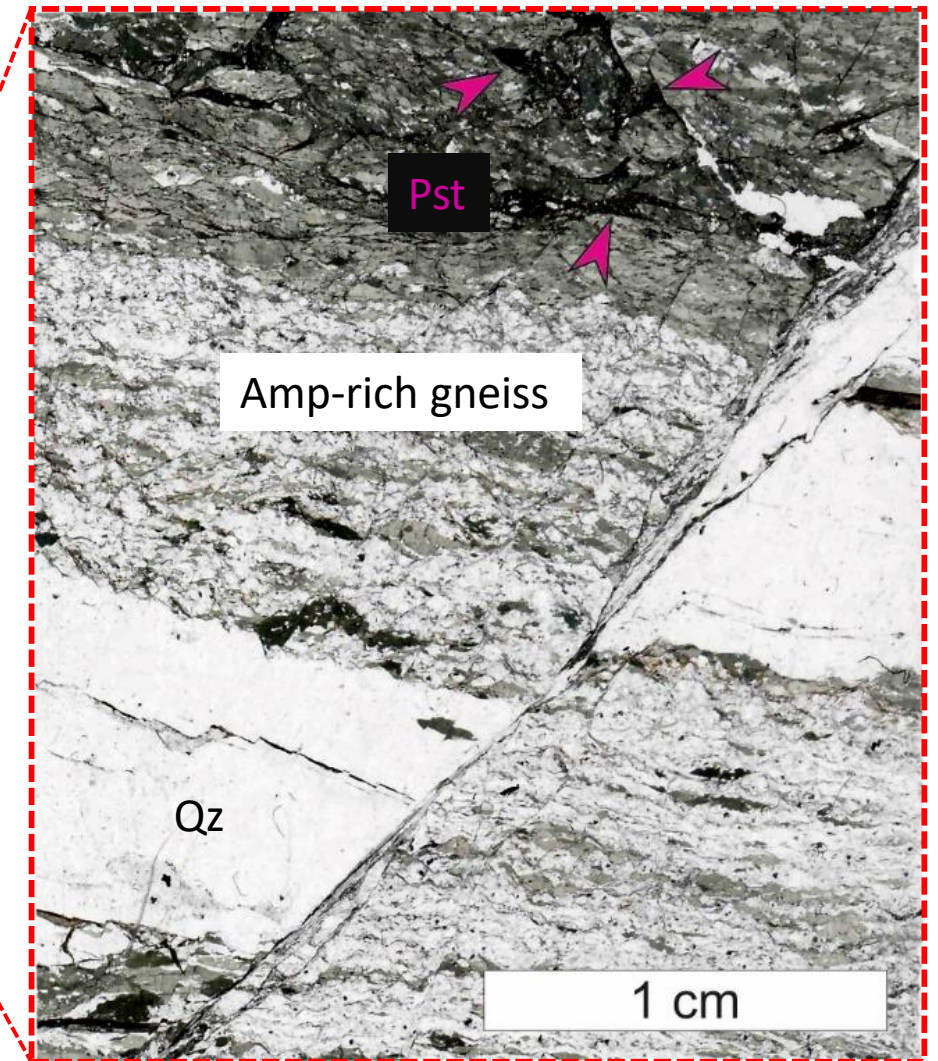
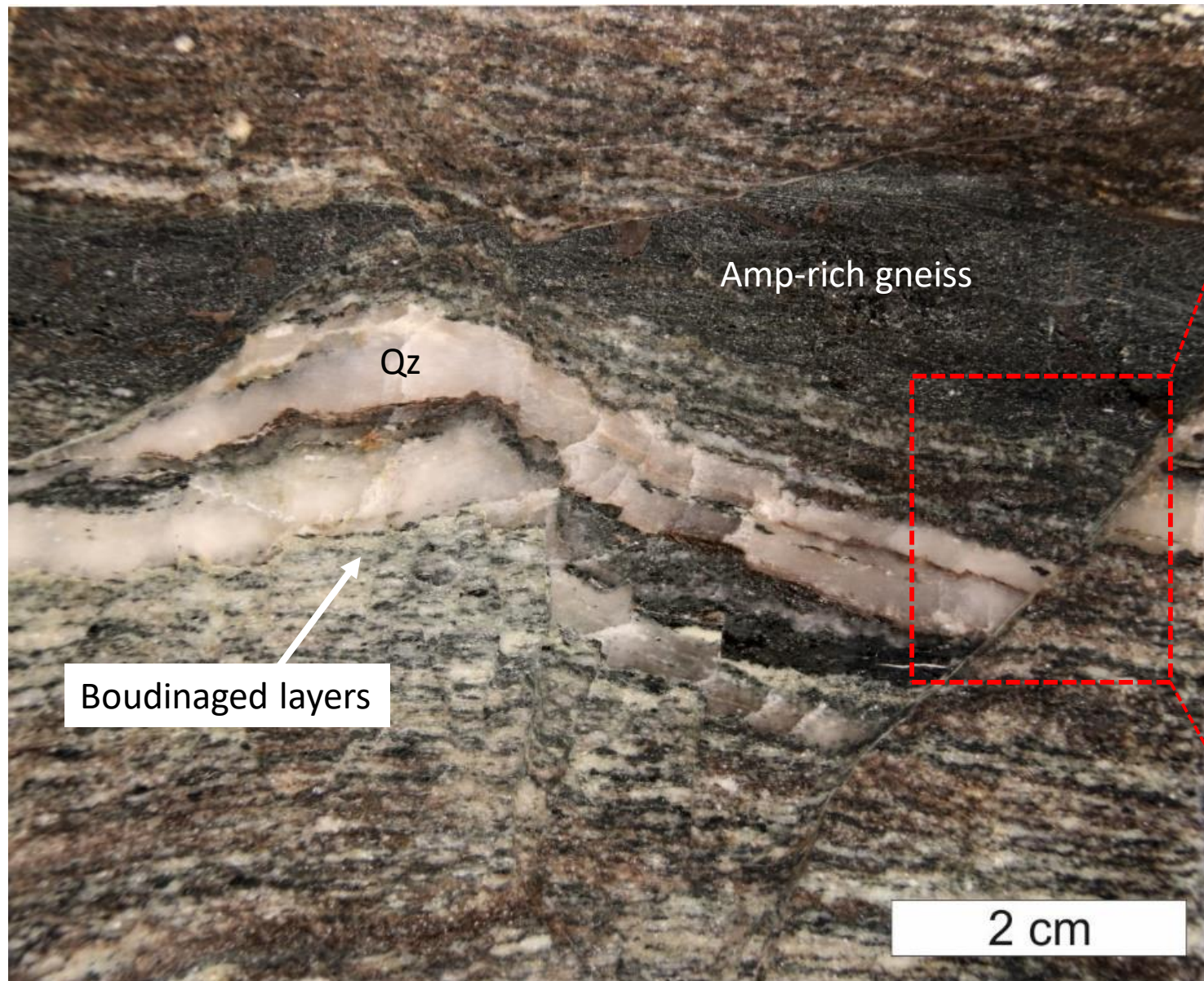
High-stress crystal plasticity of amphibole and quartz in pseudotachylyte-bearing gneisses and dislocation creep in concordant quartz-rich layers from the Silvretta basal thrust (Austria)



Lisa M. Brückner, Claudia A. Trepmann

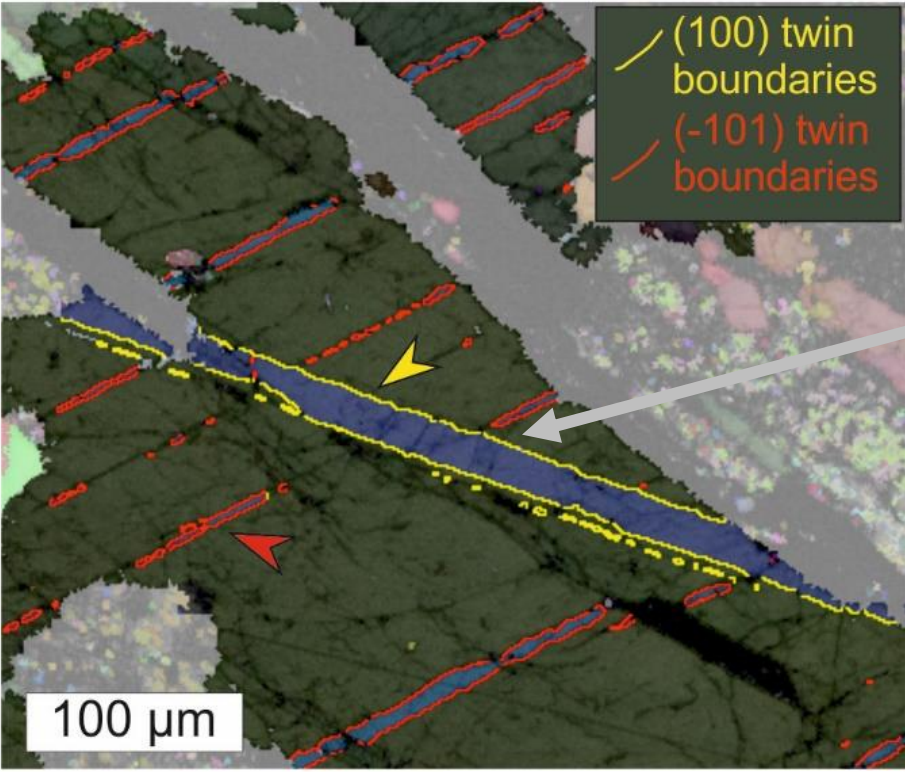
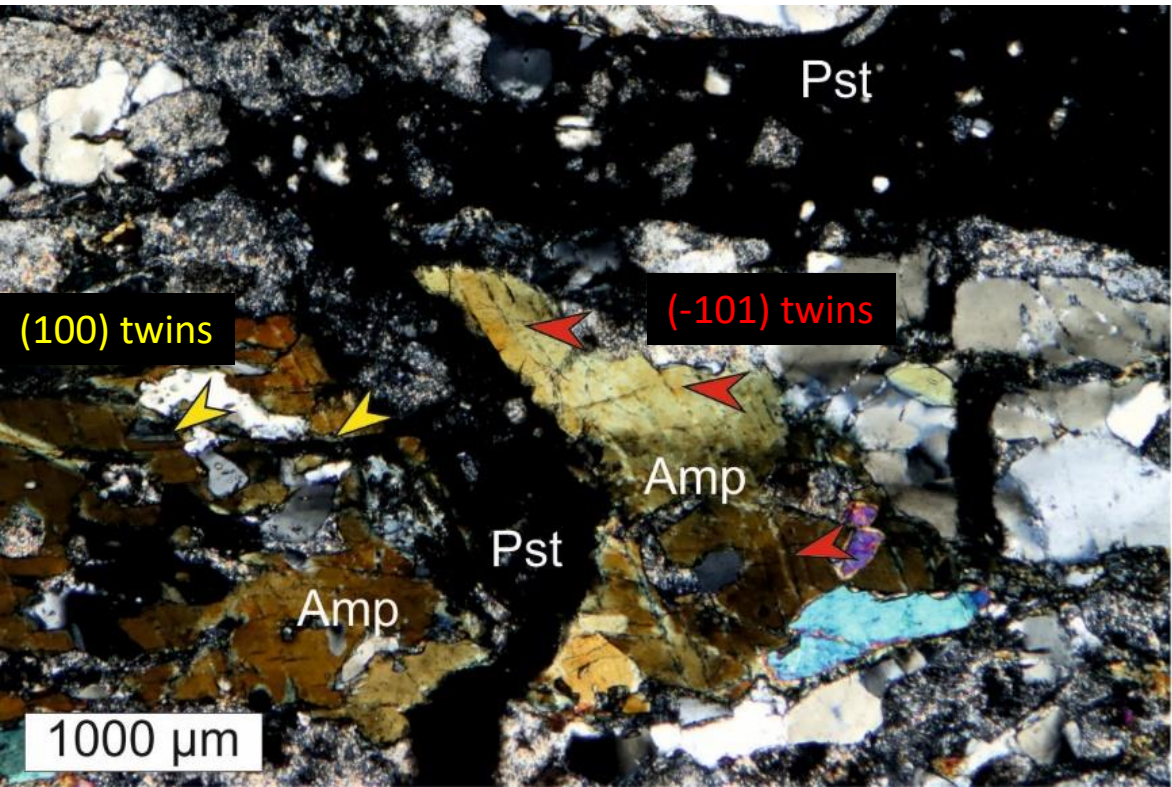
Department of Earth and Environmental Sciences, Ludwig Maximilians-University Munich, Luisenstraße 37, DE-80333 München, Germany

Fault rocks of Silvretta crystalline basal thrust (Austria):



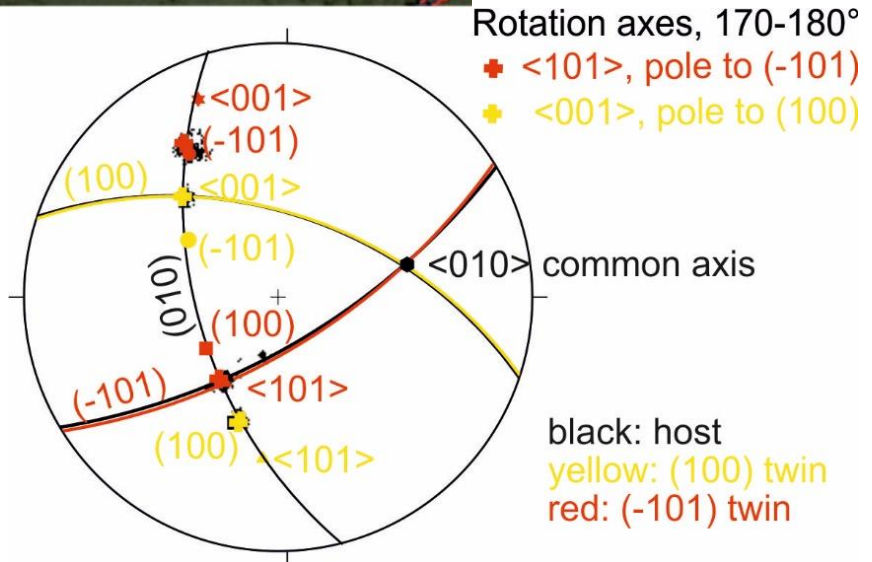
Motivation: Constraining the stress history by analyzing the deformation behavior of amphibole and pseudotachylytes in relation to the quartz microfabric

Twinned amphibole (Amp) in contact to a pseudotachylyte (Pst): **High-stress crystal plasticity of amphibole**

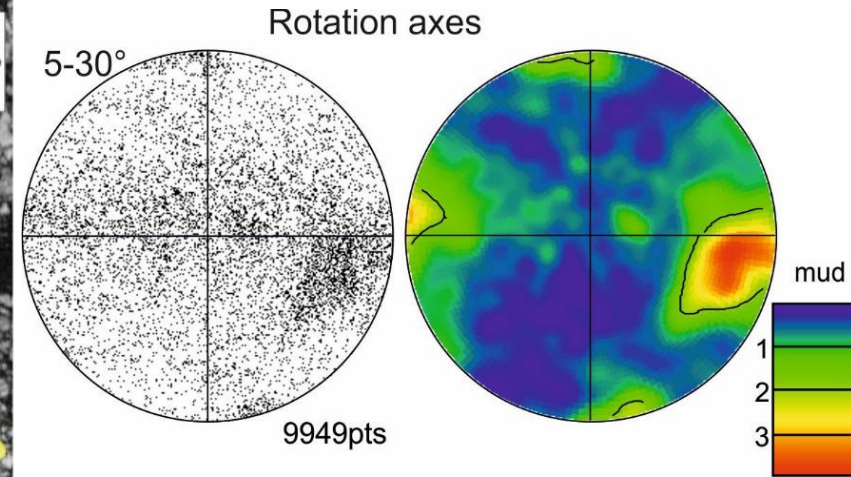
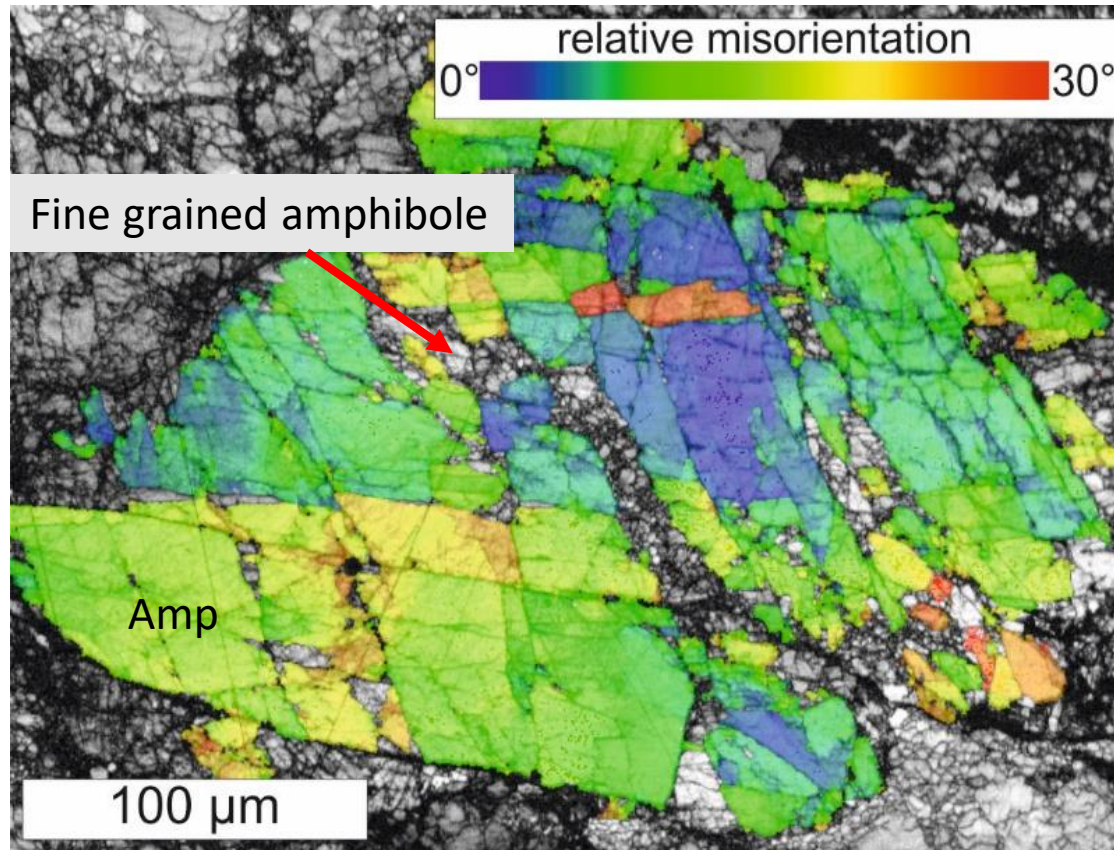


(100) twins appear to crosscut (-101) twins

- Amphibole shows:
- Two twin systems: (-101)[101] and (100)[001]
 - Undulatory extinction
- (-101) twins $\rightarrow$ high differential stresses of ≥ 400 MPa

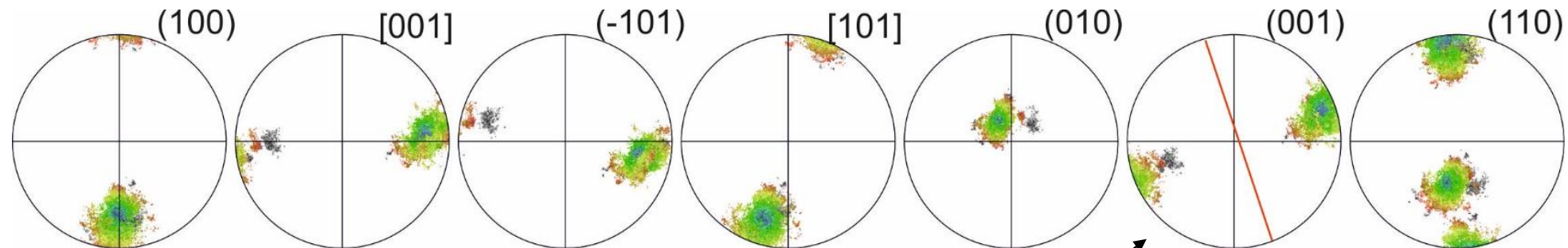


Distributed microcracking and undulatory extinction of amphibole analyzed via EBSD:



Rotation axes to this undulatory extinction reveal no clear systematic orientations

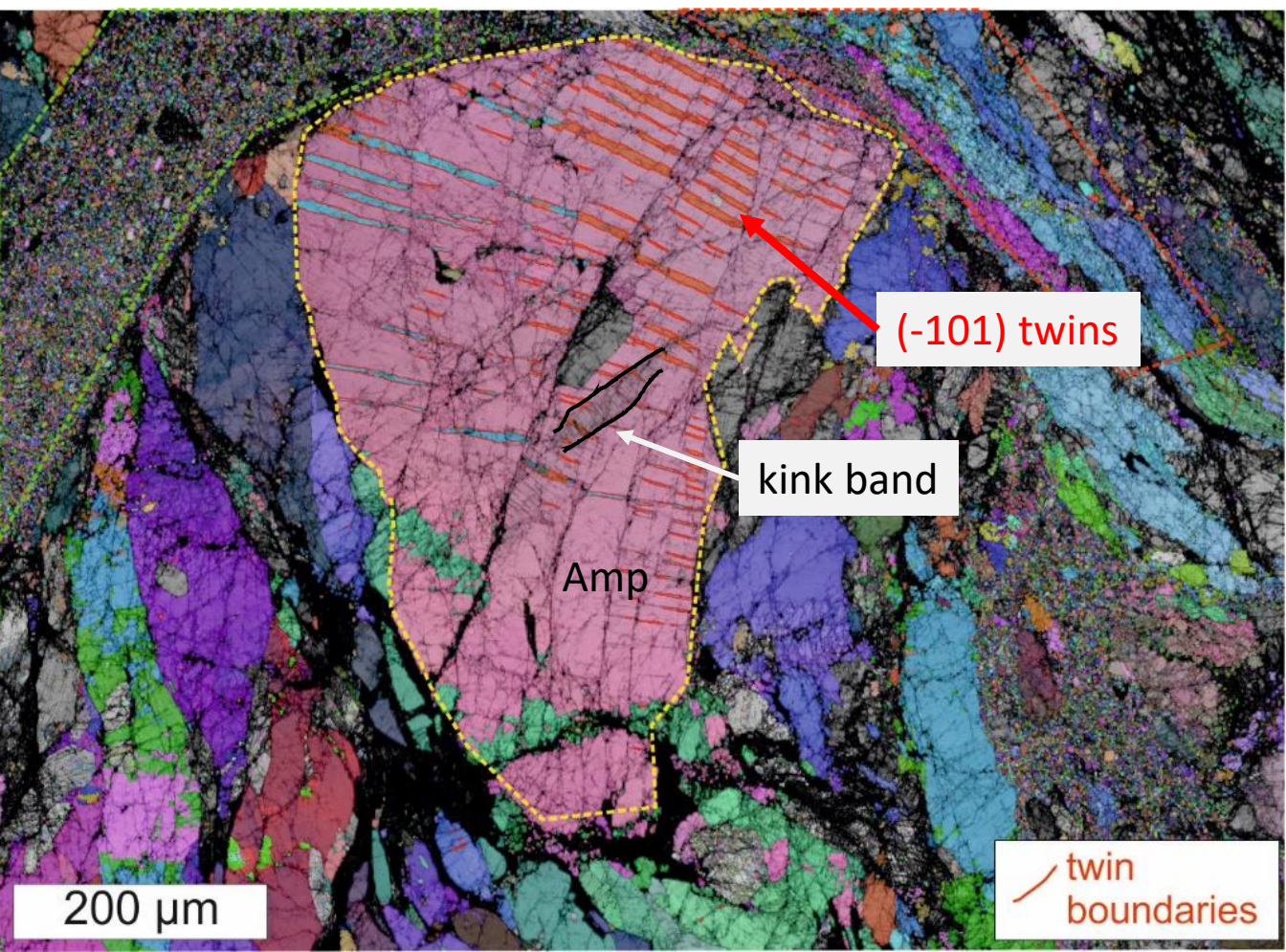
Relative misorientation appears to be related to sets of subparallel microfaults
→ rigid body rotation of the fragments



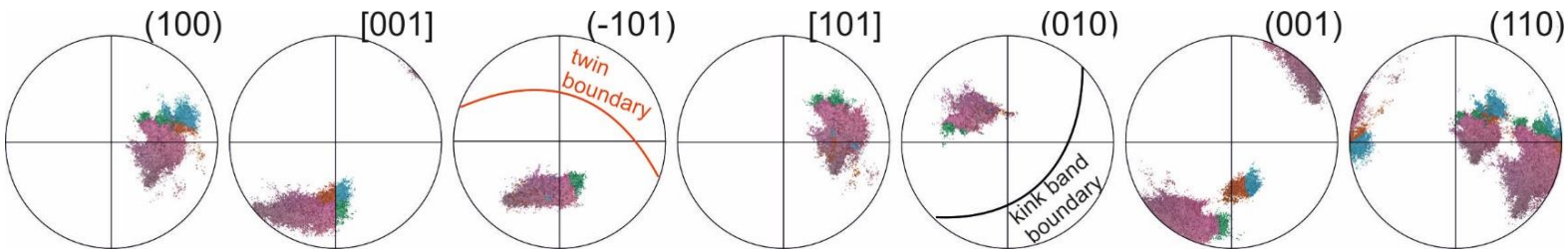
Microfaults appear subparallel to (001)

Fine grained amphibole (< 30 μm) can occur:

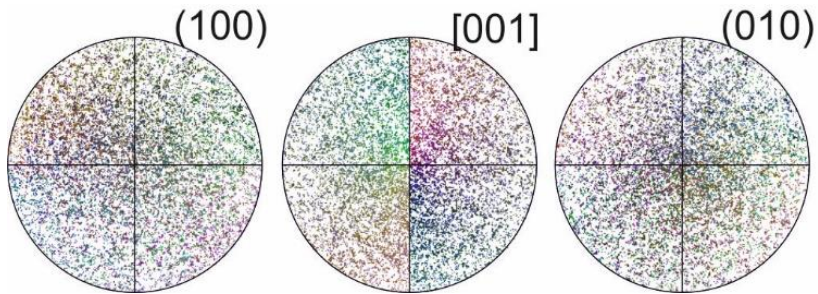
- as clasts within pseudotachylytes (red-rimmed area)
- along strongly deformed grains (green-rimmed area)
- along microfaults (see one slide before)



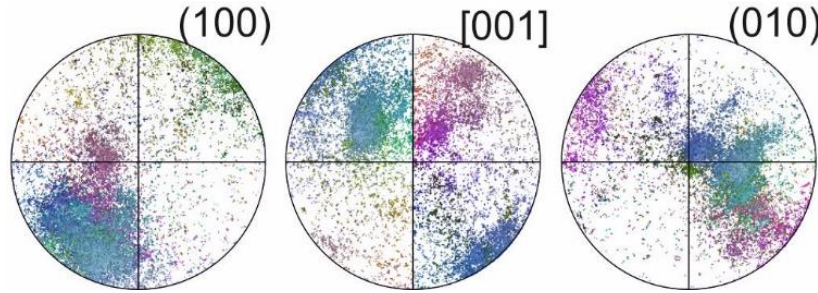
Yellow-rimmed area



Green-rimmed area



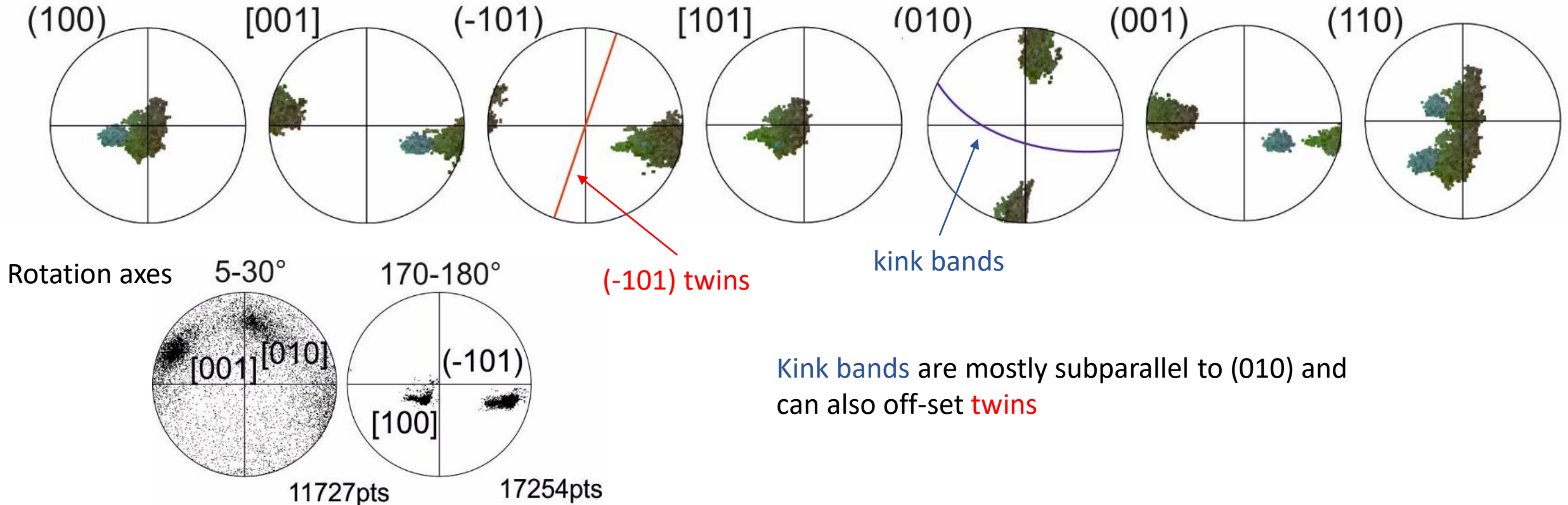
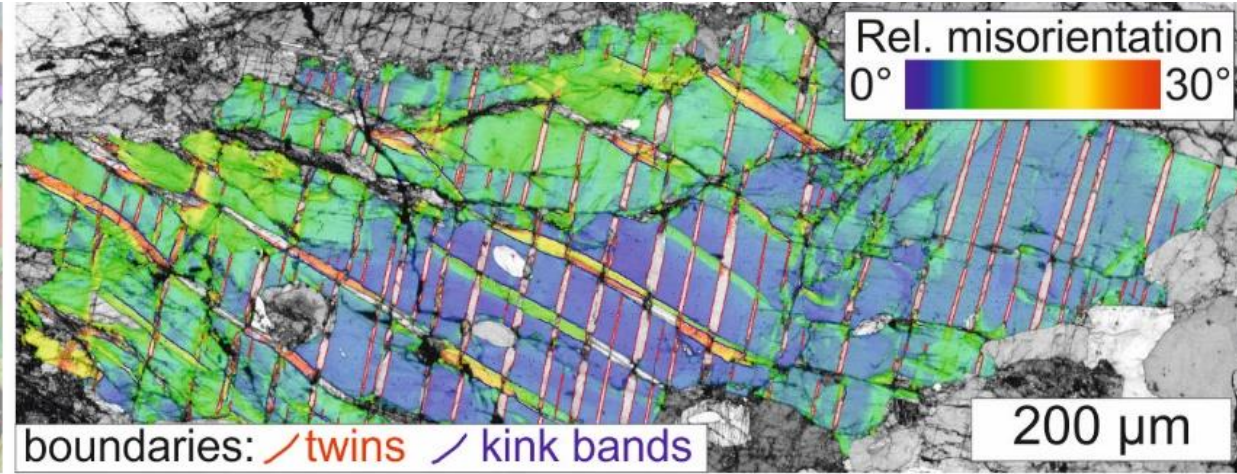
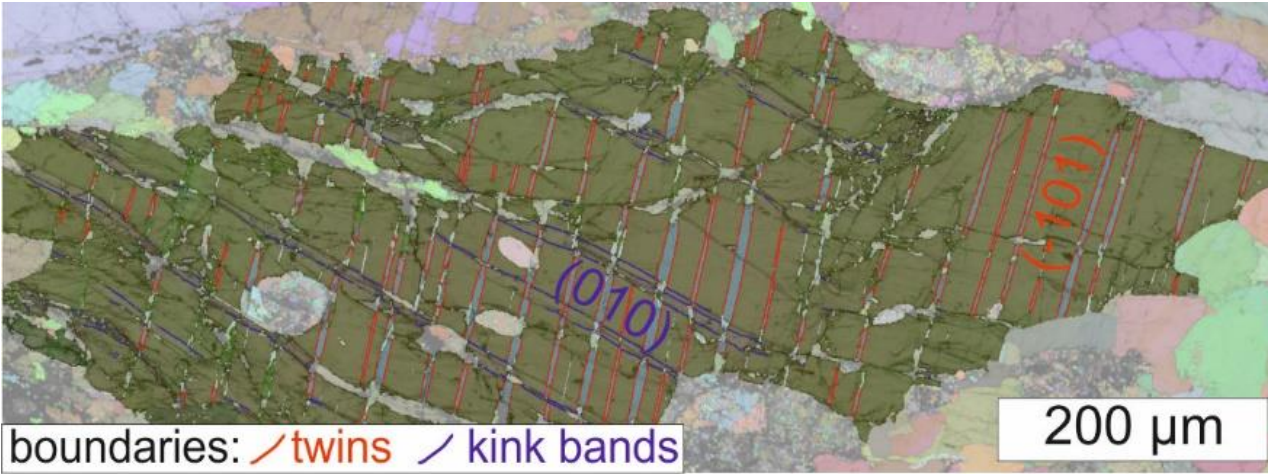
Red-rimmed area

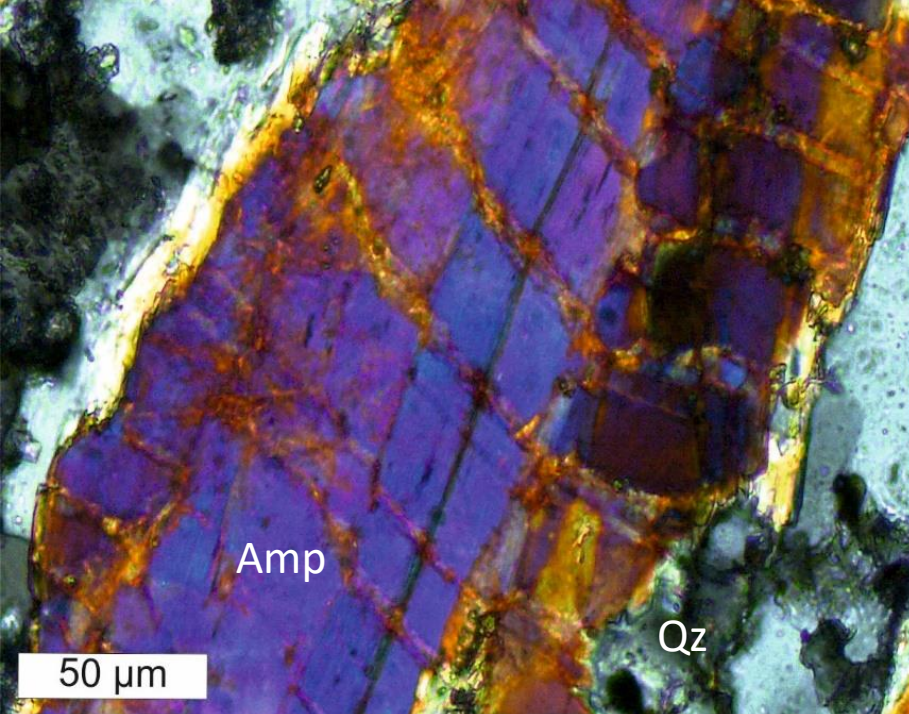


Orientations of fine grained amphibole show no systematic crystallographic orientation relationship

→ Subsequent nucleation and growth at lower stresses

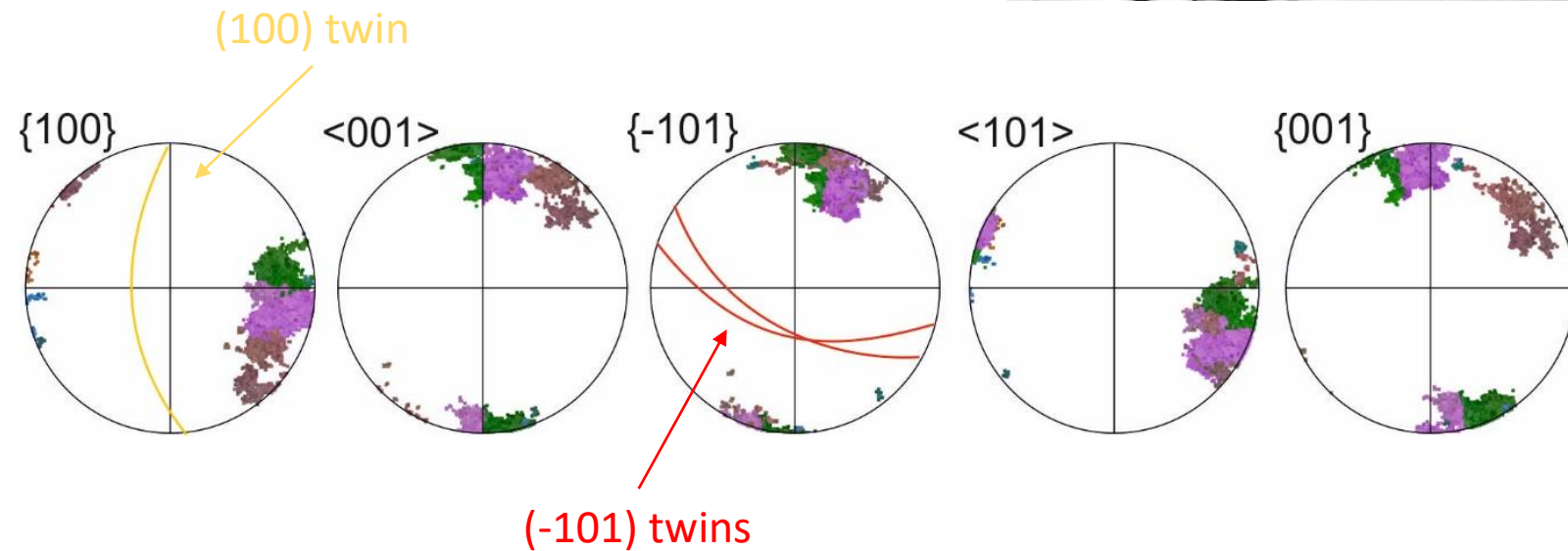
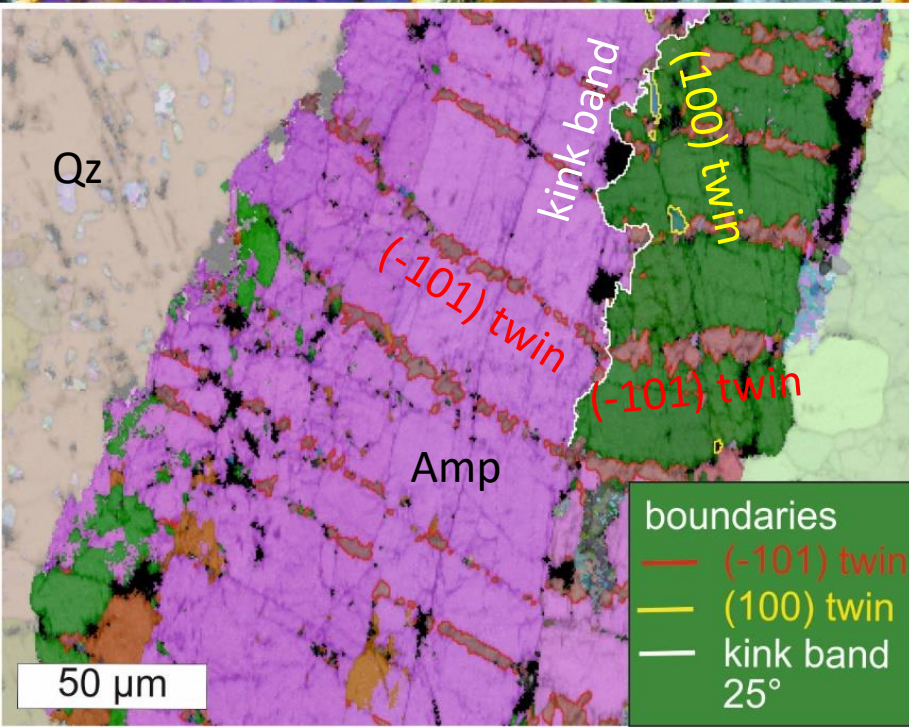
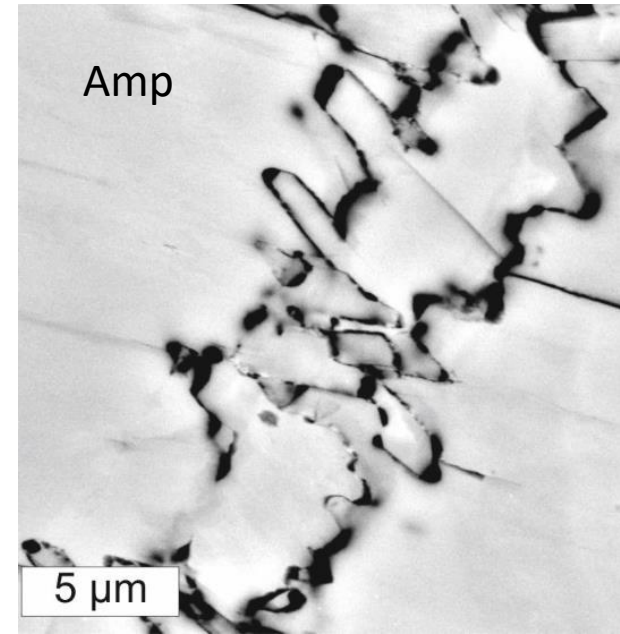
Kinking of amphibole:



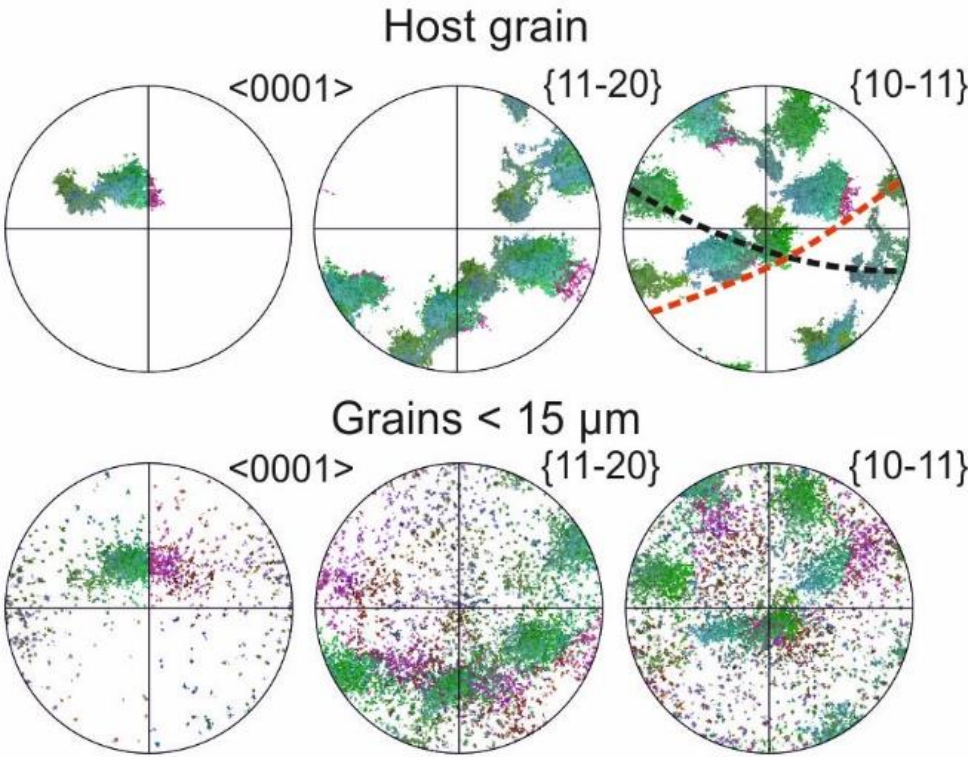
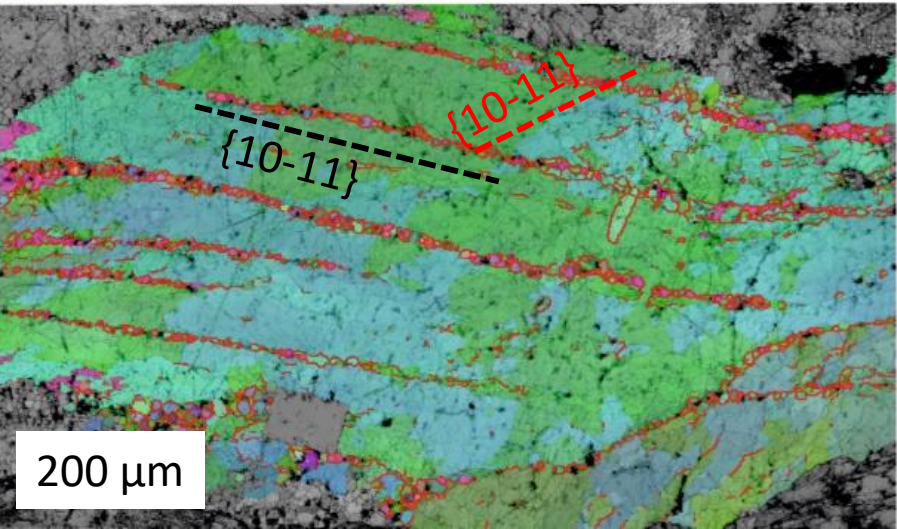
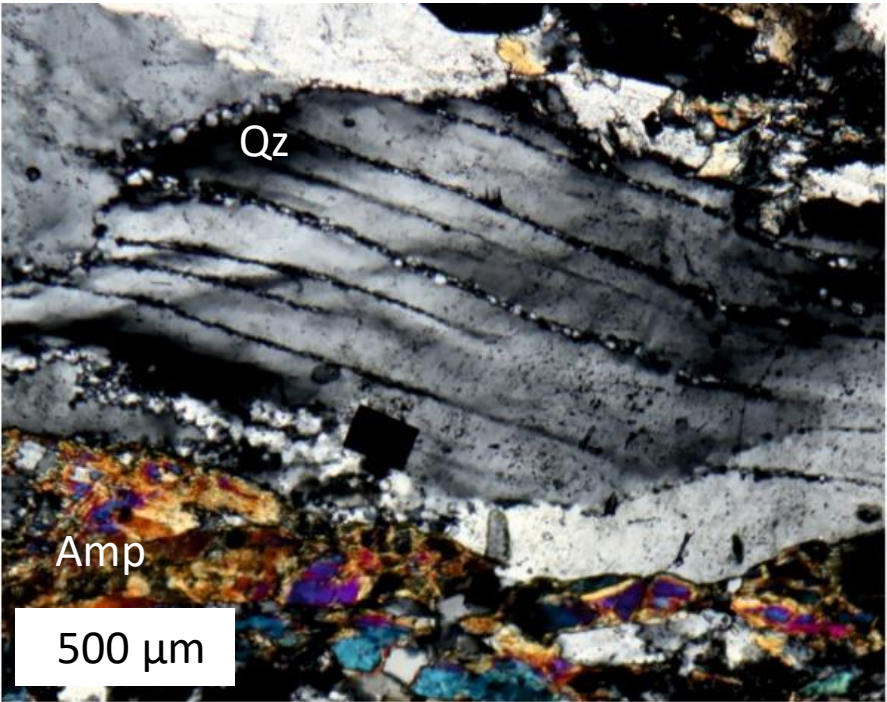


Twin boundaries and kink band boundaries mostly show straight boundaries but can also be sutured

Grain boundary migration after twinning and kinking at lower stresses compared to the twinning



Quartz in relation to twinned amphibole and pseudotachylytes:



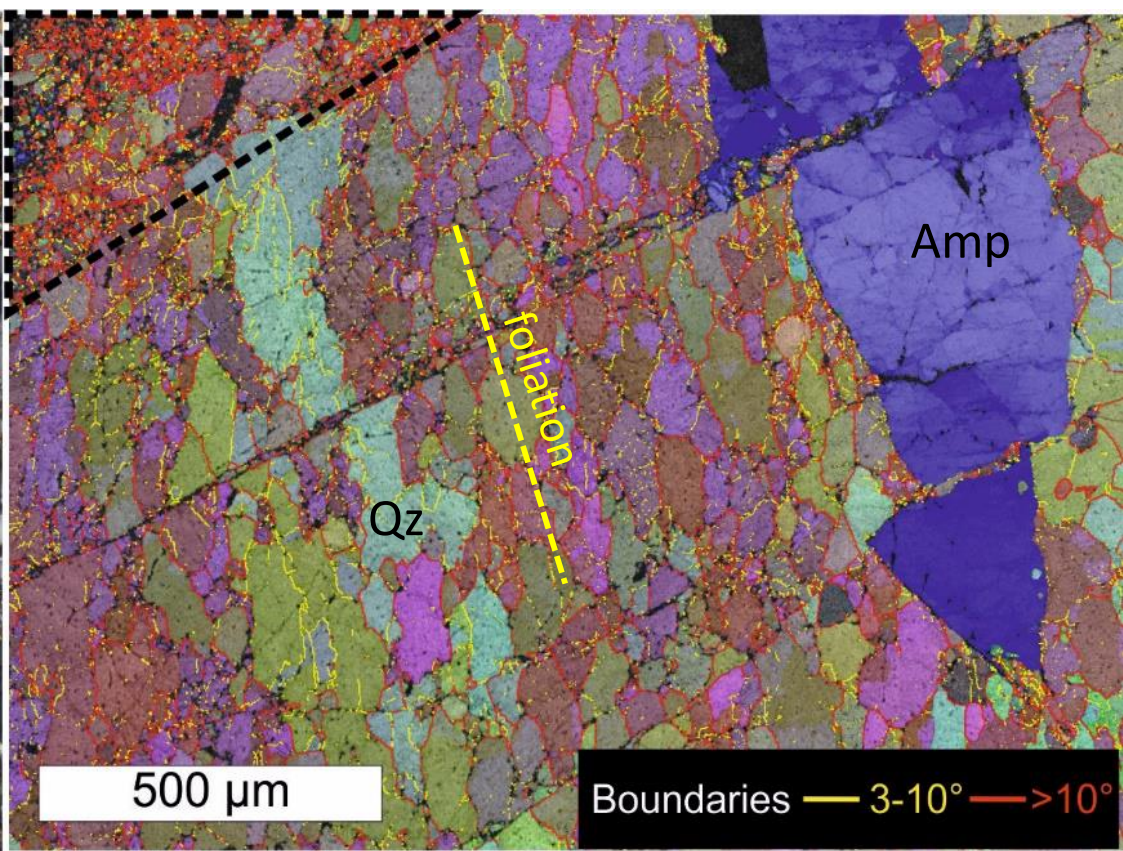
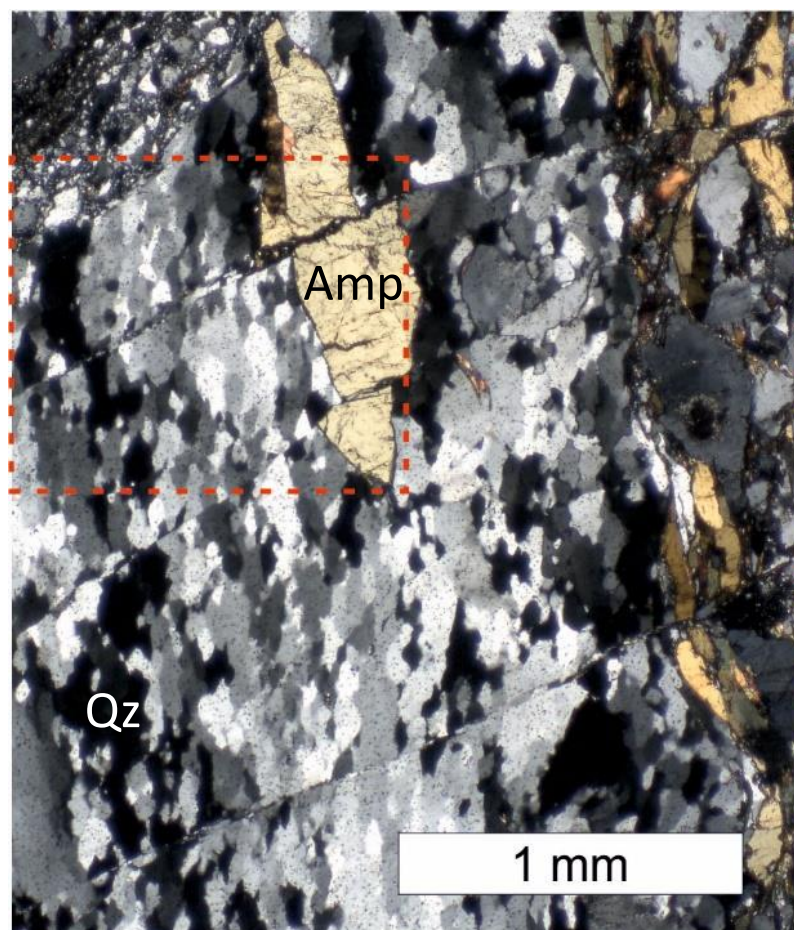
Orientations of fine recrystallized grains ($< 15 \mu\text{m}$) along rhombohedral planes deviating largely from that of the host grain

Microstructures indicate high-stress dislocation glide-controlled crystal plasticity

High-stress crystal plasticity microstructures occur exclusively in spatial relation to twinned amphibole and pseudotachylytes and are not related to the quartz-amphibole-gneiss contact !

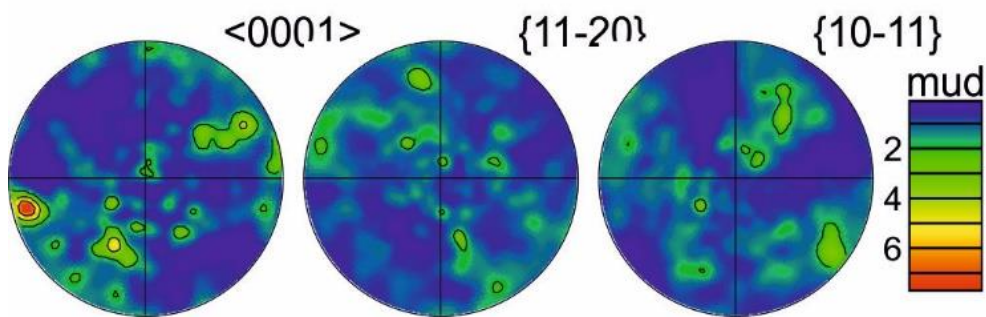
→ High-stress crystal plasticity of quartz formed coeval to high-stress crystal plasticity of amphibole and pseudotachylytes

Quartz microfabrics in quartz-rich concordant layers:

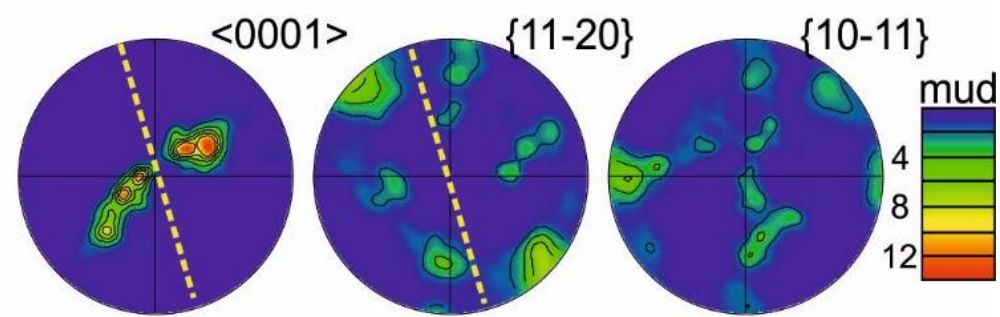


- Homogeneous fine-grained aggregates with CPO
- Subgrains with similar shape and size compared to recrystallized grains
- Transgranular fractures cut through recrystallized quartz microfabric with related cataclasis of quartz
- Cataclastically deformed quartz can be related to the fractures

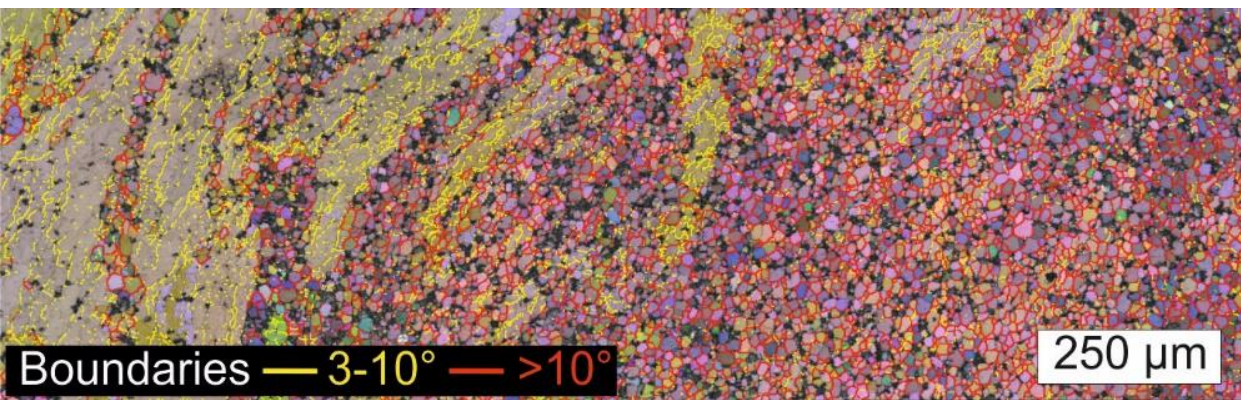
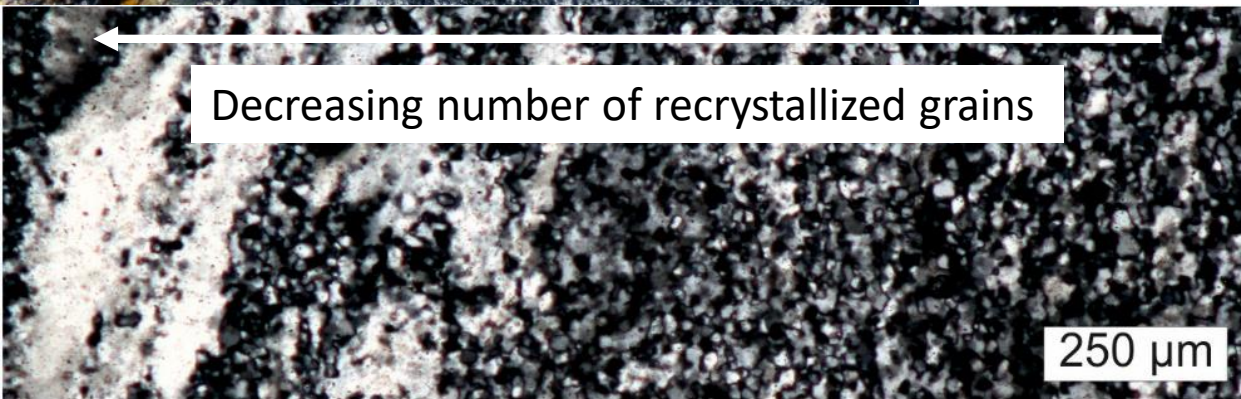
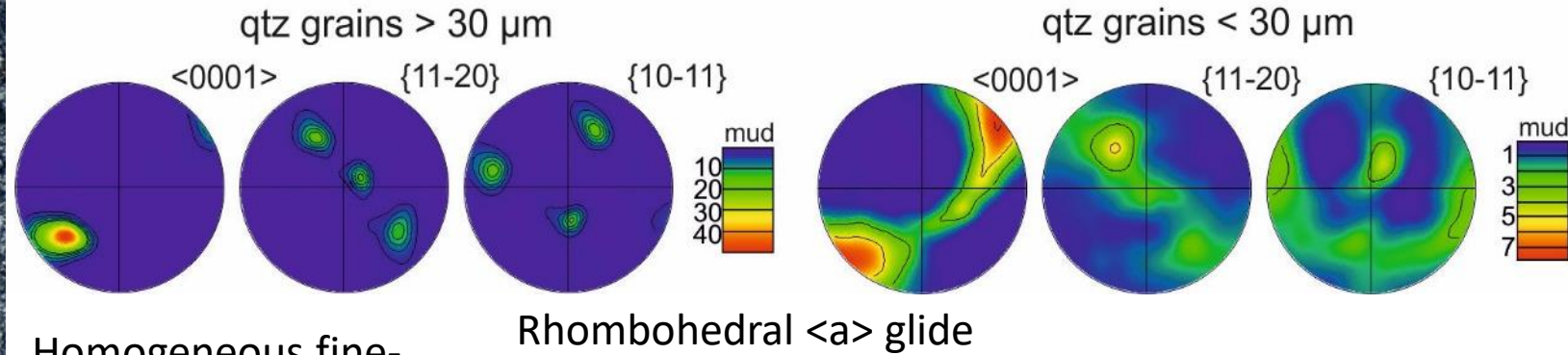
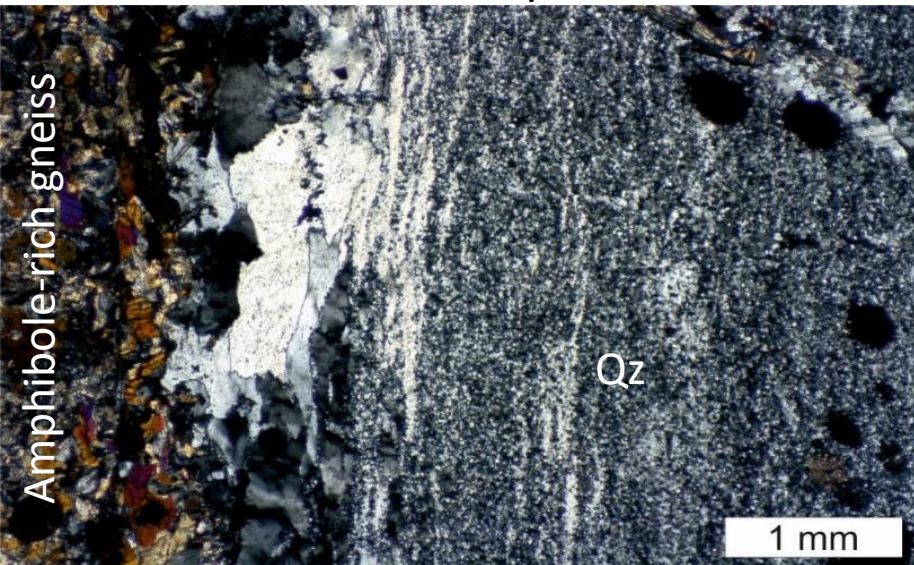
cataclastically deformed quartz, black-rimmed area



recrystallized quartz



Quartz microfabrics in quartz-rich concordant layers: **Dislocation creep with dynamic recrystallization**



Subgrains with similar shape and size compared to recrystallized grains → subgrain rotation recrystallization

Grain size of 15 μm indicates ~ 80 MPa

No indication of increased strain towards the lithological contact! But:

Decreasing number of recrystallized grains towards the amphibole layer → decreasing strain by dynamic recrystallization (“strain shadow”)

Dislocation creep represents a separate stage, predating pseudotachylyte formation and related high-stress crystal plasticity of quartz and amphibole

Amphibole microstructures with undulatory extinction, mechanical twinning, kink bands and distributed microcracking **record dislocation glide-controlled deformation** in the **low-temperature plasticity regime**

High stresses of **> 400 MPa indicated by (-101) twinning of amphibole** → directly related to cataclasis, pseudotachylyte formation and quartz deformation controlled by dislocation glide

No relationship of these high-stress microstructures to the lithological contact !

Missing spatial relationship of quartz recrystallization microfabric **to pseudotachylytes** and observed **“strain shadow”**:
→ creep in the quartz-rich lithologies cannot explain the high differential stresses recorded by the crystal-plasticity of amphibole and quartz and the associated pseudotachylyte formation

Amphibole-rich gneisses accumulated a higher amount of strain during high-stress/high-strain rate deformation

At a **preceding stage of deformation** (few tens of MPa): **quartz layers** were **deformed by dislocation creep** indicated by homogeneously recrystallized grains with CPO

During creep stage: quartz-rich lithologies were accumulating a higher amount of strain in comparison to amphibole

➡ **High stresses during pseudotachylyte formation cannot be explained by crystal-plastic instabilities during creep of the quartz-rich lithologies !**