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Hydrothermal fluids and faulting interplay: microstructural investigation of syntectonic prehnite- epidote-bearing fault rocks (northern Victoria Land, Antarctica)

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Natural fault rocks represent excellent materials to investigate and understand the complex mechanical processes occurring during faulting. The microstructural and petrologic investigations of these rocks can provide useful information both on the active deformation mechanisms, and the interactions between permeating fluids and rocks during faulting as well as indications about the age of deformation.
Here we focus on a fault zone hosted in paleozoic granitoids (Granite Harbour Intrusives) from the northern Victoria Land (TransAntarctic Mountains – TAM - Antarctica). The studied fault is part of a ENE-WSW km-scale fault system that transects the TAM, with a long lasting history of reactivation from Paleozoic to Cenozoic time. These faults were affected by multiple reactivations and are characterised by the occurrence of mylonite to cataclasite/ultracataclasites and pseudotachylytes. At places fault rocks are associated to metasomatic alteration and recrystallization. The damage zones thickness may vary from cm to dm scale with various degrees of pinkish to greenish metasomatic alteration.
In this work we present the study of a cm-thick detachment from one of the above fault systems, characterised by superposed prehnite/epidote-rich slip zones and microveins.
The host rock is a granitoid with pluri-mm-size euhedral to subhedral crystals of K-feldspar, plagioclase, biotite and quartz (plus minor zircon and apatite). The studied damage zone is about 2 cm-thick with a 2 cm-thick altered wallrock, where the magmatic minerals are partially or completely replaced by saussurite and sericite, chlorite, epidote, prehnite and minor sphene. The wall-rock is cut by tiny epidote veins.
The damage zone consists of different generations of mm-wide dark-green (DG) to light-green (LG) ultracataclasite layers and recrystallized pseudotachylyte.
Electron microprobe and EBSD analyses show that:
- DG layers mainly consist of epidote replacing clasts of K-feldspar, albite, quartz; here two generations of epidote occur: the oldest one (1) is deformed and is surrounded by new undeformed epidote grains (2) that grew with no preferential fabric.
- LG layers are prehnite-rich, include fragments of dark-green layers and clasts of K-feldspar, albite, quartz and epidote; rare deformed prehnite (1) with a coarser grain-size occurs, being replaced by new micron-size prehnite (2) that grew with no preferred orientation. Locally the light-green layers are made of sigmoidal clasts containing deformed K-feldspar and dynamically recrystallized albite, surrounded by micron-size prehnite after main cataclastic flow.
We suggest that the studied fault zone recorded various cycles of reactivation with multiple pulses of Ca-rich fluids having varying T (<350°C) and fCO_2 (generally both decreasing) and acted as a preferential pathway for the degassing of the system. Analyzing the deformation mechanisms of epidote and prehnite crystals, we propose that fluid-assisted deformation and metamorphic reactions caused the periodic softening (after grain-size reduction) and strengthening (growth of prehnite felt) of different domains of the fault rock and the consequent repeated shifting of strain localization during space and time within the shear zone.
We moreover highlight how the occurrence of (hydrated) minerals gradually cementing the fault zone could have strong consequences on the seismic/aseismic behaviour of the detachment.