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Microstructural record of pressure solution and crystal plastic deformation in carbonate fault rocks from a shallow crustal strike-slip fault, Northern Calcareous Alps (Austria)

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This study presents microstructural investigations of natural carbonate fault rocks that formed by a suite of different deformation processes, involving hydro-fracturing, dissolution-precipitation creep and cataclasis. Some fault rocks show also clear indications of crystal plastic deformation, which is quite unexpected, as the fault rocks were formed in an upper crustal setting, raising the question of possible strongly localised, low temperature ductile deformation in carbonate rocks.

The investigated carbonate fault rocks are from an exhumed, sinistral strike-slip fault at the eastern segment of the Salzachtal-Ennstal-Mariazell-Puchberg (SEMP) fault system in the Northern Calcareous Alps (Austria). The SEMP fault system formed during eastward lateral extrusion of the Eastern Alps in the Oligocene to Lower Miocene. Based on vitrinite reflectance data form intramontane Teritary basins within the Northern Calcareous Alps, a maximum burial depth of 4 km for the investigated fault segment is estimated. The investigated fault accommodated sinistral slip of several hundreds of meters.

Microstructural analysis of fault rocks includes scanning electron microscopy, optical microscopy and electron backscattered diffraction mapping. The data show that fault rocks underwent various stages of evolution including early intense veining (hydro-fracturing) and stylolite formation reworked by localised shear zones. Cross cutting relationship reveals that veins never cross cut clay seams accumulated along stylolites. We conclude that pressure solution processes occured after hydro-fracturing. Clay enriched zones localized further deformation, producing a network of small-scale clay-rich shear zones of up to 1 mm thickness anastomosing around carbonate microlithons, varying from several mm down to some μm in size. Clay seams consist of kaolinit, chlorite and illite matrix and form (sub) parallel zones in which calcite was dissolved. Beside pressure solution, calcite microlithons show also ductile deformation microstructures, including deformation twinning, undulose extinction, subgrain rotation recrystallization and even grain boundary migration. Especially coarse grained calcites from veins localized ductile deformation and record dislocation glide.

The investigated fault rocks are excellent examples of frictional, pressure solution and crystal plastic deformation processes. We speculated that crystal plastic deformation typical for higher metamorphic shear zones in marbles, can be either produced under much lower temperature conditions or the temperature necessary for crystal plastic deformation was generated by frictional slip or strain heating within the fault zone.