Exploitation of unsuitably oriented foliation by localized mylonites and pseudotachylytes (Tauern Window, Eastern Alps)

Giovanni Toffol1, Giorgio Pennacchioni1, Luiz Fernando Grafulha Morales2, and Simone Papa1

1Department of Geosciences, University of Padova, Padua, Italy
2Structural Geology and Tectonics Group, ETH Zürich, Zürich, Switzerland

During exhumation, metamorphic rocks change their rheological behavior from dominantly ductile to brittle. Especially at the “brittle-ductile transition” at the bottom of the brittle crust, which coincides roughly with the domain where most “shallow” earthquakes nucleate, rocks exhibit a close interplay between ductile flow and fracturing.

In the Neves area (Tauern window, Eastern Alps) the exhumation across the brittle-ductile transition of amphibolite-facies meta-granitoids during the Alpine cycle is recorded by the association of pseudotachylyte veins and localized low-grade mylonites (stage-2 deformation). The stage-2 structures exploited the precursor amphibolite-facies foliation within meter-thick mylonites (stage-1 deformation) and were in turn overprinted by epidote-chlorite-bearing shear fractures and veins (stage-3 deformation). The kinematics and orientation of stage-1 and stage-3 structures indicate a slight rotation of the regional shortening direction from 345° to about 360°. This implies that stage-2 mylonites and pseudotachylytes developed at a high angle to the shortening direction.

The syn-kinematic metamorphic assemblage of stage-2 mylonites includes quartz, oligoclase (Ab75), biotite, epidote, and minor muscovite and K-feldspar; garnet was not stable. This assemblage constrains the deformation at upper greenschist facies condition and temperatures of around 400 °C. During mylonitization the coarse-grained (mm-sized) amphibolite-facies quartz recrystallized by subgrain rotation to ultra-fine (~ 3 µm average grain size determined from EBSD maps) aggregates. Such a small grain size yields differential stress > 200 MPa during stage-2 mylonitization, considering the piezometer of Cross et al., 20171.

Pseudotachylytes are in a close spatial association with stage-2 mylonites and share the same sense of shear. There is no evidence of a ductile overprint of pseudotachylytes. The stage-2 structures developed at a very high angle to the inferred shortening direction, which implies that the coseismic slip occurred on planes with a very low friction coefficient (estimated <0.3), contradicting the high differential stress estimated for the mylonites. We infer a genetic relationship between stage-2 mylonite and pseudotachylyte. Mylonites progressively formed the mica-rich foliation planes, continuous over large distances, that provided the weak mechanical anisotropy eventually leading to coseismic slip.
Reference: