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Seismic and aseismic deformation along large fault zones – an example from the base of the Silvretta crystalline, Engadine window, Central Alps

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Pseudotachylytes are a clear evidence for deformation at seismic velocities. They occur within several geological environments: very impressive examples exist from meteorite impacts, smaller veins of frictional melt are produced along fault zones during earthquakes. Even land-slides seem to be able to generate enough heat to create pseudotachylytes.

We investigated the distribution of pseudotachylytes at the base of the Silvretta crystalline basement along the northern rim of the Engadine window within the Central Alps of Europe. The study area, which is located at the Austrian-Swiss border, comprises the boundary zone between Austroalpine nappes (African plate) in the hanging wall and Penninic nappes (oceanic domain between the African and European plates) in the footwall. Pseudotachylytes as evidence for frictional heating occur immediately above the boundary zone between the Penninic and Austroalpine nappes within a zone of some 100 m width. Pseudotachylytes crop out in layers, networks or breccia zones. The thickness of the pseudotachylyte veins ranges from a few mm up to several dm. They contain clasts of different size, either angular or subrounded. In some examples the clasts are concentrated in the internal part of the pseudotachylyte vein pointing to flow processes within a melt. Microscopic investigations exhibit a very fine grained groundmass with no evidence of residual melt. Nevertheless, sparse spherolites indicate recrystallization processes from a former melt phase. Injection veins at outcrop and thin section scale corroborate the assumption of a previous existence of melt produced by frictional heating. Mutual crosscutting of pseudotachylyte veins with mylonitic shearzones, which are indicators for aseismic stable sliding, is visible both at

macroscopic and microscopic scale. In addition, some pseudotachylytes found directly at the base of the Silvretta crystalline exhibit a strong mylonitic overprint. Their matrix shows a distinct foliation, embedded clasts display a well pronounced shape preferred orientation as well as evidences for intercrystalline deformation.

The mutual crosscutting relation between pseudotachylytes and mylonitic shearzones and the overall mylonitic overprint of pseudotachylytes indicates an alternation of seismic and aseismic deformation. This either points to a transition zone below the seismogenic zone, or to transient changes in the slip regime within a not completely coupled seismogenic zone. Previously published pressure estimates of about 3 kbar to 6 kbar and temperatures of less than 350˚C for the wall rocks favored the latter explanation.