Scaling seismic fault thickness from the laboratory to the field

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Pseudotachylytes originate from the solidification of frictional melt, which transiently forms and lubricates the fault plane during an earthquake. Here we observe how the pseudotachylyte thickness a scales with the relative displacement D both at the laboratory and field scales, for measured slip varying from microns to meters, over six orders of magnitude. Considering all the data jointly, a bend appears in the scaling relationship when slip and thickness reach □1 mm and 100 μm, respectively, i.e. $M_W > 1$. This bend can be attributed to the melt thickness reaching a steady□state value due to melting dynamics under shear heating, as is suggested by the solution of a Stefan problem with a migrating boundary. Each increment of fault is heating up due to fast shearing near the rupture tip and starting cooling by thermal diffusion upon rupture. The building and sustainability of a connected melt layer depends on this energy balance. For plurimillimetric thicknesses ($a > 1$ mm), melt thickness growth reflects in first approximation the rate of shear heating which appears to decay in $D^{-1/2}$ to D^{-1}, likely due to melt lubrication controlled by melt + solid suspension viscosity and mobility. The pseudotachylyte thickness scales with moment M_0 and magnitude M_W; therefore, thickness alone may be used to estimate magnitude on fossil faults in the field in the absence of displacement markers within a reasonable error margin.