



**HAL**  
open science

## Scaling seismic fault thickness from the laboratory to the field

Thomas P. Ferrand, Stefan Nielsen, Loïc Labrousse, Alexandre Schubnel

► **To cite this version:**

Thomas P. Ferrand, Stefan Nielsen, Loïc Labrousse, Alexandre Schubnel. Scaling seismic fault thickness from the laboratory to the field. EGU General Assembly 2021 (online), Apr 2021, Online, France. 10.5194/egusphere-egu21-12188 . hal-03554522

**HAL Id: hal-03554522**

**<https://hal.science/hal-03554522v1>**

Submitted on 3 Feb 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

EGU21-12188

<https://doi.org/10.5194/egusphere-egu21-12188>

EGU General Assembly 2021

© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.



## Scaling seismic fault thickness from the laboratory to the field

Thomas P. Ferrand<sup>1</sup>, Stefan Nielsen<sup>2</sup>, Loïc Labrousse<sup>3</sup>, and Alexandre Schubnel<sup>4</sup>

<sup>1</sup>Institut des Sciences de la Terre d'Orléans, Université d'Orléans / CNRS UMR-7327, Orléans, France.

<sup>2</sup>Department of Earth Sciences, Durham University, Durham DH1 5ED, United Kingdom.

<sup>3</sup>Institut des Sciences de la Terre de Paris, Sorbonne Université, Campus Pierre et Marie Curie / CNRS UMR-7193, Paris, France.

<sup>4</sup>Laboratoire de Géologie de l'Ecole Normale Supérieure, PSL Research University / CNRS UMR-8538, Paris France.

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  $\approx 1$  mm and  $100 \mu\text{m}$ , 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.