Seismic Energy Partitioning Inferred from Pseudotachylyte-bearing Faults (Gole Larghe Fault, Adamello batholith, Italy)

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Aim of this study
Partitioning of the earthquake energy between fracture energy \( E_a \) (energy required to create new rupture surface in the slip zone and a damage zone in the wall rock) and frictional heat \( E_f \) determines the features of the rupture propagation and the mechanical behavior of a seismic fault. The \( E_a/E_f \) ratio cannot be inferred from seismological investigations. We propose to use the cataclastic microstructures associated with pseudotachylyte (solidified friction melt produced during coseismic slip) to constrain the \( E_a/E_f \) ratio.

Methods
1. We selected a pseudotachylyte-bearing fault, that records one single seismic rupture, from an exhumed fault exposed in the Adamello batholith (Gole Larghe Fault zone, Italy, Pan.1).
2. We estimated \( E_a \) by energy balance calculations (Pan.2).
3. We estimated \( E_f \) by:
   a. SEM and FE-SEM image analysis of fragmented plagioclase survivor clasts within the pseudotachylyte and fracture patterns in the host rock.
   b. Clast Size Distribution (CSD) and fracture density by computer-aided image analysis.

Results & Conclusions
The above estimates yield \( E_a = 23.3 \text{ MJ m}^{-2} \) and \( E_f \) in the range of 0.110-0.500 MJ m\(^{-2}\).

We conclude that, for this local seismic energy balance estimate, \( E_a \) is negligible compared to \( E_f \) (Pan.5).

Pan.1-Geological Setting
Geological map of the Adambello batholith (in gray). Location of the map (black box) is shown in the inset. The yellow star marks the studied area.

Pan.2-Estimate of \( E_h \)
From Ref. 2:
\[
E_h = [(1-q) \cdot H + c_p \cdot (T_m - T_f) \cdot \rho \cdot 2w]
\]
where \( q \) = ratio clasts/pt matrix (0.2) (Fig.4a), \( H \) = latent heat of fusion (3.28 \times 10^5 J kg\(^{-1}\)), \( c_p \) = the specific heat (1180 J kg\(^{-1}\) K\(^{-1}\)), \( T_m \) = initial friction melt temperature (1723 K), \( T_f \) = host rock temperature (523 K), \( \rho \) = melt density (2350 kg m\(^{-3}\)), and \( 2w \) = average pseudotachylyte thickness.

For the 5.9 \times 10^{-3} m thick fault shown in Pan.3:
\[
E_h = 23.3 \text{ MJ m}^{-2}
\]

Pan.3-Fault profile

Pan.4-Estimate of \( E_a \)

Pan.5 - Conclusions
Our study yields a local estimate of \( E_a/E_f \) in the range 0.005-0.02. Assumption that the amount of energy radiated as seismic waves \( (E_f) \) represents the 0.1-10% of the total energy of an earthquake (Ref.6), we suggest the partitioning of \( E_a \) and \( E_f \) reported in the pie-diagram below for this local context.

References: