Earthquakes Melt Rocks

Modelling Molten Rock in Faults

Key Points

- Magma (melt) generated by friction arising from earthquakes, called pseudotachylytes, can be heated by internal friction, preventing solidification and prolonging their liquid phase
- The melt's role in stopping or lubricating the host fault depends on the amount of frictional heating, which in turn depends on the volume of melt and the speed of the fault movement

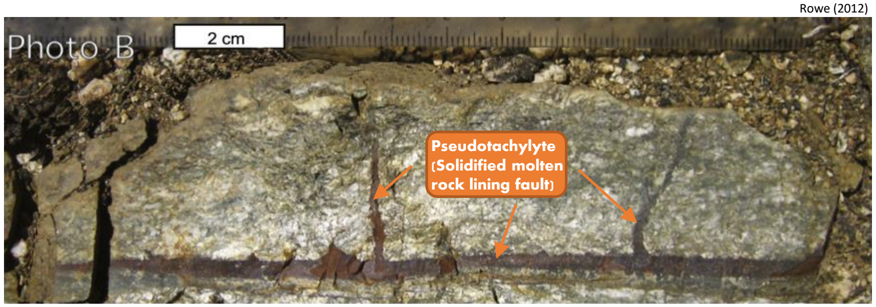
Motivation

- Veins of molten rock generated by friction in faults during earthquakes can control the size of earthquakes by solidifying (cooling) and prematurely arresting the host fault, or remaining liquid (hot) for long enough to lubricate the fault
- Viscous heating (dissipation) can heat the melt through internal friction as the earthquake shears it, controlling the thermal and material evolution of the melt
- The effects of viscous heating in this setting have not been deeply explored in past modelling work

Methods and Model

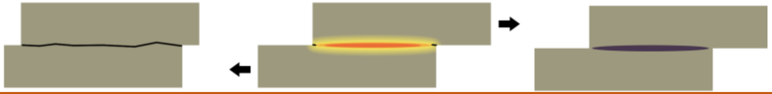
- COMSOL 5.5 was used to recreate a finite-element model of a moving, melt-filled fault
- A thin (<10mm) plane of liquid was heated by shearing and allowed to cool via conduction
- The temperature and viscosity (degree of solidification) were simulated as the earthquake died out

Rowe (2012)



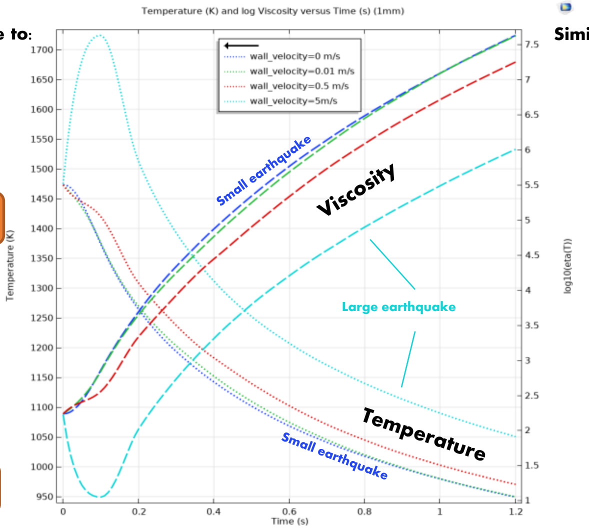
How Pseudotachylytes Form

Fault is locked → Earthquake, Fault walls melt → Melt solidifies, Pseudotachylyte formed



Results

Similar Temperature to: Blowtorch; Lava erupting from Kilauea; Melting Point of Aluminum



Similar Viscosity to: Solid Glass; Vaseline; Sour Cream; Honey

- Sufficiently large earthquakes raise the melt's temperature greatly, and lower its viscosity by orders of magnitude, promoting lubrication and delaying solidification-assisted braking
- The thickness of the melt layer and the speed of the fault movement (earthquake) are the main controls on the amount of heat generated by viscous heating
- Small and large magnitude earthquakes may exhibit different seismic characteristics as the inter-fault melt solidifies at different rates

Remaining Challenges

- Improving the realism of the earthquake speeds (dynamic vs purely kinematic)
- Incorporating dynamic traction between the melt and the solid fault wall

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Photo credit: Christie Rowe

undergraduate poster showcase