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Grain size assisted thermal runaway: a mechanism to generate intermediate-depth earthquakes and ductile shear zones

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The nucleation processes of intermediate-depth earthquakes as well as ductile shear zones are an enigmatic topic. Here we present fully coupled thermomechanical models which investigate the interplay between grain size evolution and shear heating and the impact of this feedback loop on intermediate-depth earthquake generation and shear zone formation. When grain growth is inhibited, grain size reduction facilitates the occurrence of thermal runaway, as critical stresses needed to initiate thermal runaway are significantly reduced. Grain size reduction significantly weakens the rock prior to thermal runaway and increases rheological contrasts. Once thermal runaway occurs, a pseudotachylite is formed which is embedded in a mylonite matrix.

More recently it has also been suggested that dislocation accommodated grain boundary sliding might significantly contribute to the formation of localized ductile shear zones. In the framework of our models, we test this hypothesis and evaluate the importance of different deformation mechanisms on the occurrence of grain size assisted thermal runaway. Results indicate that although dislocation accommodated grain boundary sliding has some impact, peak stresses and thus also thermal runaway are much more affected by low-temperature plasticity. As the parameters of low-temperature plasticity are still highly uncertain, this result highlights the importance of additional research to better constrain the parameters for low-temperature plasticity.