EGU21-7752, updated on 28 Jan 2022
https://doi.org/10.5194/egusphere-egu21-7752
EGU General Assembly 2021

The slip behavior of velocity-weakening fault barriers

Diego Molina[1,4], Jean-Paul Ampuero[5], and Andres Tassara[3,4]
[1]Universidad de Concepción, Ciencias de la Tierra, Departamento de geología, Concepcion, Chile (diegmolinao@gmail.com)
[3]Universidad de Concepción, Ciencias de la Tierra, Departamento de geología, Concepcion, Chile (andrestassara@udec.cl)
[4]Millennium Nucleus The Seismic Cycle Along Subduction Zones, Valdivia, Chile
[5]Seismological Laboratory, California Institute of Technology, Pasadena, CA, USA

Subduction earthquakes are among the most devastating natural hazards across the planet and yet the factors controlling their size remain poorly understood. It is thus important to investigate the mechanisms controlling rupture arrest and runaway, in particular the nature of rupture barriers (areas where earthquakes tend to stop). Geodetic and seismic observations along several faults suggest that barriers are mostly creeping (low seismic coupling). It is often interpreted that creeping barriers are governed by velocity-strengthening friction (VS), which is a sufficient condition for stable slip. However, some barriers have been observed to host intermediate magnitude earthquakes or to be completely ruptured by a large earthquake. Therefore, the frictional properties of seismic barriers may not be restricted to VS. In particular, the possibility of velocity-weakening (VW) areas behaving as barriers needs to be further explored.

In this work, we characterize the multiple behaviors of seismic barriers on faults governed by velocity-weakening (VW) rate-and-state friction, using earthquake cycle simulations. We consider a 2D model, where a central VW area has a larger critical slip distance (Dc) or higher normal stress (σ) than the surrounding VW areas. We found that the central areas can behave as permanent or temporal barriers to earthquake propagation if their Dc or σ are large enough. On permanent barriers, creep occurs steadily. However, on temporary barriers, the locking degree changes throughout the cycle, despite frictional properties remaining constant.

To understand the efficiency of VW barriers (that is, to determine under what conditions they can stop ruptures), we use fracture mechanics theory. We found that barrier efficiency depends mainly on the ratio between the fracture energy of the barrier, which is proportional to Dc and normal stress, and the energy release rate of the neighboring seismic segment, which is proportional to its stress drop squared and length. If geological features of the overriding and subducting plates affect Dc and σ on the megathrust, our results support the idea of structural controls on the seismic behavior of megathrusts. Thus, understanding how geological features are linked to fracture energy may contribute to seismic hazard assessment by constraining rupture arrest and multi-segment ruptures in earthquake scenarios.