Criticality of cascade-up and its dependence on velocity on various fault geometry

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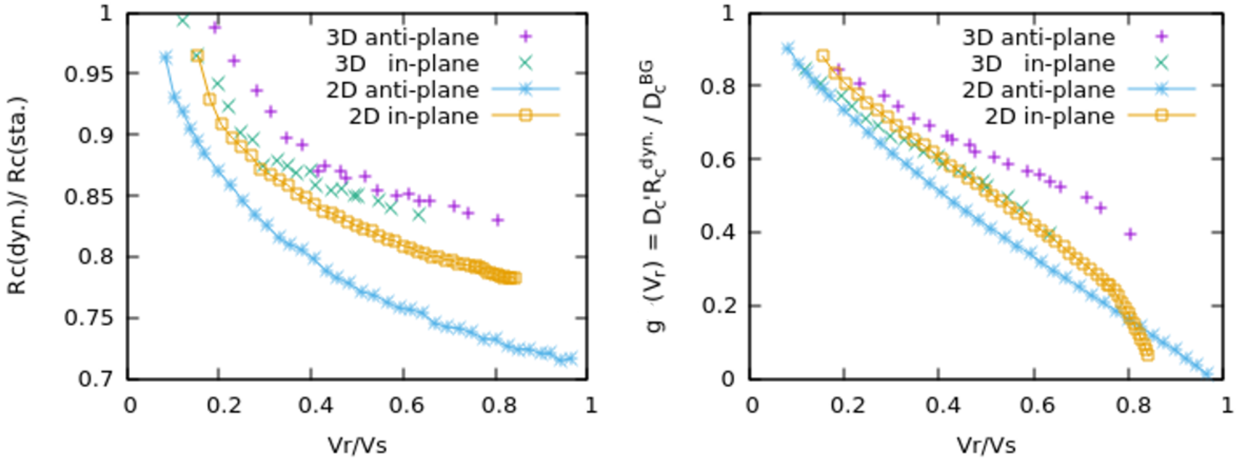
Could rupture propagation be interpreted as continuing cascading-up process under fluctuation due to heterogeneity? Seismological observations (Ellsworth and Beroza, 1995; Uchide and Ide, 2007; Meier et al. 2016) suggest that there is no specific scale in initiation process, and rupture is influenced by fault heterogeneity during its growing phase. Criticality of cascading-up or halt is going be discussed in this study in the same way which many conventional studies have done for quasi-static rupture growth (e.g., Andrews, 1976; Day, 1982; Rubin and Ampuero; 2005).
We examined the situation that self-similar crack with constant rupture velocity(V_r) in a small patch encounters surrounding barrier region of unique larger fracture energy. There is a minimum patch size ($R_c^{dyn.}$: the critical dynamic crack size of the fault) that crack cascades up in surrounding region, depending the fracture energy of barrier. If the patch is larger than $R_c^{dyn.}$, its rupture speed once decelerates but afterwards it spontaneously accelerates once the crack size exceeds the static critical crack size ($R_c^{sta.}$).

$R_c^{dyn.}$ is obtained in this study by numerical simulation using BIE method of Mode II, III (Tada and Madariaga, 2000) and three-dimensional elliptical crack (Fukuyama and Madariaga, 1998). We gave following slip-weakening distance to a planer fault with homogeneous stress (T_p: yield strength, T_e: uniform stress, μ: rigidity). H[x] is Heaviside function. D_c is discontinuous at $R^{dyn.}$.
$D_c(r) = D_c' \ r \cdot H[R^{dyn.}-r] + D_c^{BG} \cdot H[r-R^{dyn.}]$

The result, the proportion of $R_c^{dyn.}/R_c^{sta.}$ is obtained as a function of rupture velocity for each fault geometry, where both $R_c^{sta.}$ and V_r are functions of $\mu T_p D_c' \ /T_e^2$.
or, proportion of discontinuity of fracture energy at $R_c^{dyn.}$ is also written in a similar form.
i.e., $R_c^{dyn.}=(V_r)\ R_c^{sta.}$ and $D_c^{BG}=g(V_r)\cdot D_c' \ R_c^{dyn.}$
Both $f(V_r)$ and $g(V_r)$ is qualitatively similar in Mode II, III, and three-dimensional crack, which is depicted in attached figure.

These results may suggest that rupture with fast rupture velocity (~0.7V_s) is far more capable of cascading-up in barrier made by fault heterogeneity than that of slow rupture velocity (~0.1V_s)

Keywords: scale independent rupture initiation, criticality of cascade up


Rc(dyn.)/ Rc(sta.)
1
0.95
0.9
0.85
0.8
0.75
0.7
0
0.2
0.4
0.6
0.8
1
Vr/Vs
3D anti-plane
3D in-plane
2D anti-plane
2D in-plane
g (Vr) = Dc'Rc dyn. / Dc BG
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
Vr/Vs
3D anti-plane
3D in-plane
2D anti-plane
2D in-plane