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The initiation of brittle faults in crystalline rock

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Abstract

Faults in the upper crust initiate from pre-existing (inherited) or precursory (early-formed) structures and typically grow by the mechanical interaction and linkage of these structures. In crystalline rock, rock architecture, composition, cooling, and exhumation influence the initiation of faults, with contrasting styles observed in plutonic rocks, extrusive igneous rocks, and foliated metamorphic rocks. Brittle fault growth in granitic rock is commonly controlled by the architecture of inherited joints or preexisting dikes. In basalt, abundant joints control the surface expression of faulting and, enhanced compliance due to abundant joints leads to folding and deformation asymmetry in the fault zone. Highly reactive mafic minerals likely become rapidly evolving fault rocks. In foliated metamorphic rocks, fault initiation style is strongly influenced by strength anisotropy relative to the principal stress directions, with fracturing favored when the foliation is aligned with the directions of principal stress. The continuity of micas within the foliation also influences the micromechanics of fault initiation. Brittle kink bands are an example of a strain-hardening precursory structure unique to foliated rock. Each of these fault initiation processes produces different initial fault geometry and spatial heterogeneity that influence such properties as fault permeability and seismogenesis.

1. Introduction

Detailed study of small faults has illuminated the processes by which faults initiate and grow in the upper crust. Several decades of research address these processes in