Dynamic rupture and seismic waves in structures with bimaterial interfaces: Theory and observations

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Theoretical studies indicate that in-plane rupture along a bimaterial interface between different elastic solids has remarkable dynamic properties. These include spontaneous evolution to narrow slip pulses with strong dynamic crack-tip dilation, which propagate preferentially in the direction of motion of the slower solid [1]. These properties can be relevant to multiple important issues including the heat flow paradox, earthquake rise-times and expected shaking hazard near large bimaterial faults [2]. A preferred propagation direction of ruptures is expected to produce over multiple earthquake cycles asymmetric rock damage across the fault, with more damage on the side with faster seismic velocity at depth [3]. The existence and properties of bimaterial interfaces can be best imaged with fault zone head waves that spend much of their propagation path along bimaterial interfaces [4]. The symmetry and other properties of damaged fault zone layers can be mapped with trapped waves that result from constructive interference of critically-reflected waves [5] and direct geological studies. Analyses of seismic fault zone waves and geological signals in sections of the San Andreas, North Anatolian and other larger faults reveal strongly asymmetric shallow rock damage, as expected for bimaterial ruptures associated with the local velocity contrasts [6]. Systematic examination of spatial symmetry properties of earthquakes along 25 faults in CA shows, in agreement with the theoretical expectations, strongly asymmetric patterns in early-time spatially-close aftershocks along large faults with prominent bimaterial interfaces, with enhanced activity in the directions predicted for the local velocity contrasts, and absence of significant asymmetry along most other faults [7].

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