# Numerical simulations of the generation of fault zone trapped waves

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To understand the detailed structures of fault fracture zones would be important for studying the earthquake preparation process therein. Since fault zone trapped waves are considered a useful tool for this purpose, they have been studied theoretically as well as observationally. Most of the past theoretical studies on the trapped waves were based on numerical wave simulations, modeling a fault zone by a homogeneous low-velocity layer (e.g., Ben-Zion 1998). It is known, however, that real fault zones often include densely distributed fault-parallel cracks. Murai (1994) modeled a fault zone by a low-velocity layer with a constant thickness in which many 2-D fault-parallel cracks are densely distributed. He located a SH-wave line source in the zone, whose dynamic response was then investigated. His simulations revealed that the existence of low-velocity layers appears essential to the generation of fault zone trapped waves; the cracks could not by themselves generate them. It may be expected, however, that in his simulation geometry the SH waves would impinge on the cracks nearly parallel and hence would not effectively interact with them. SV wave propagation must be considered for discussing whether the trapped waves could be generated by crack scattering only.

In this study, we perform SH and P-SV wave simulations for a fault fracture zone model very close to Murai's (1994). We adopt here a standard second-order velocity-stress finite difference method (Virieux 1984, 1986). The cracks are assumed to be stress-free planes, expressed on the computation grids in the manner of Suzuki et al (2003, 2004). We use an antiplane single force to generate SH wavelets isotropically, and an inplane single couple to generate SV wavelets effectively in the fault-parallel direction; the dominant wavelength are close to the crack size. Like Murai (1994), we define fault zone trapped waves as long-period wave trains following the direct waves. The simulations reveal that, if the crack density is extremely high (say, 1.6), trapped SH waves can occur even without a low velocity layer, contrary to Murai's (1994) results. This disagreement may be explained by the difference in the definitions of cracks; note that the cracks he modeled were not stress-free and thus their scattering strengths would be weaker. In the case of the SV wave source, trapped waves appear after the direct waves even for a relatively low crack density (say, 0.2) and without a low velocity layer. For higher crack densities (0.6 or more), however, the direct waves do not travel very far probably because of the strong scattering attenuation; one can also recognize long-lasting wave energy localization around the source region, characterized by highly complicated seismograms. Though not obvious within the limited computation times, a portion of the localized energy seems to propagate along the fault zone with a very low group velocity. Since the present model of distributed cracks is too simple, one should examine in future more realistic models, into which are incorporated nonrandom crack distributions, crack size distributions and frictions on the crack planes, for example.

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