Intra-sonic propagation of sliding zones in a fault

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Seismic events associated with pre-existing faults are traditionally assumed to be caused by rupture propagation, that is in-plane shear crack propagation. However what appears to be a shear crack is a sliding zone over a fault; it grows by overcoming friction (either in direct contact or in the gouge) rather than rock rupture. When modelling frictional sliding, two important factors need to be considered: (1) the elasticity of the surrounding rocks which causes self-oscillations resulting in the movement resembling stick-slip even in constant friction; (2) the rotation of real gouge particles which being non-spherical lead, in the presence of compression, to the effect of negative shear stiffness. The latter effectively works to transfer the elastic energy stored in the compressed rock into the energy of the sliding zone propagation.

This presentation introduces 1D models accounting for these factors. Both lead to the so-called telegraph equation which is a wave equation with a non-derivative term referring to the fact that the movement is considered against a stationary solid. The equation with respect to displacement corresponds to the case of apparent negative stiffness, while the equation with respect to the displacement rate corresponds to the pure frictional sliding. The rock elasticity leads to the sliding zone propagation speed equal to the p-wave velocity making the propagation speed intra-sonic [1]. The rate-dependent friction can slightly reduce the speed. It is interesting that the sliding zone propagation is related to p-wave rather than s- or Rayleigh waves as one would anticipate. The results of this research contribute to the understanding of the mechanics of seismicity.


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