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Fan-structure wave as a source of earthquake instability

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Today frictional shear resistance along pre-existing faults is considered to be the lower limit on rock shear strength at confined compression corresponding to the seismogenic layer. This determines the lithospheric strength and the primary earthquake mechanism associated with frictional stick-slip instability on pre-existing faults.
This paper introduces a recently identified shear rupture mechanism providing a paradoxical feature of hard rocks – the possibility of shear rupture propagation through the highly confined intact rock mass at shear stress levels significantly less than frictional strength. In the new mechanism the rock failure, associated with consecutive creation of small slabs (known as 'domino-blocks') from the intact rock in the rupture tip, is driven by a fan-shaped domino structure representing the rupture head. The fan-head combines such unique features as: extremely low shear resistance (below the frictional strength), self-sustaining stress intensification in the rupture tip (providing easy formation of new domino-blocks), and self-unbalancing conditions in the fan-head (making the failure process inevitably spontaneous and violent). An important feature of the fan-mechanism is the fact that for the initial formation of the fan-structure an enhanced local shear stress is required, however, after completion of the fan-structure it can propagate as a dynamic wave through intact rock mass at shear stresses below the frictional strength.
Paradoxically low shear strength of pristine rocks provided by the fan-mechanism determines the lower limit of the lithospheric strength and favours the generation of new faults in pristine rocks in preference to frictional stick-slip instability along pre-existing faults. The new approach reveals an alternative role of pre-existing faults in earthquake activity: they represent local stress concentrates in pristine rock adjoining the fault where special conditions for the fan-mechanism nucleation are created, while further dynamic propagation of the new fault (earthquake) occurs at low field stresses even below the frictional strength. However, the proximity of the pre-existing discontinuities to the area of instability caused by the fan mechanism creates the illusion of stick-slip instability on the pre-existing faults, thus concealing the real situation.