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Graviquakes and elastoquakes

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Earthquakes are dissipation of energy. Since normal faults release gravitational energy, whereas strike-slip and thrust faults dissipate elastic energy, it is useful to differentiate them into graviquakes and elastoquakes [1]. Both types of earthquakes have their magnitude controlled by the involved volume during the coseismic stage. Thrusts have the largest potential volume since the relationship between fault length and hypocenter depth may be up to about 25 times, whereas this ratio is around 10 for strike-slip faults and 3 for normal faults [2]. This can explain why thrust faults reach the highest magnitudes and the Gutenberg-Richter parameter b is lower (0.9) with respect to normal faults (1.1). Therefore, we suggest to shift the paradigm that the earthquake is simply controlled by a fault, to the concept that the energy is stored into a volume that is activated during the earthquake when the threshold of accumulation with respect to the internal static friction within the volume and the fault plane is reached. In crustal settings, the maximum volume is constrained by the depth of the brittle-ductile transition (BDT), the tectonic style and the depth of the decollement layer [3]. Lateral variations of the friction may determine creeping versus locked volumes and faults, dissipating respectively gradually or instantaneously either the gravitational or the elastic energy, hence generating variable strain rates [4]. Graviquakes and elastoquakes appear to have different, partly opposed phenomenologies. This differentiation may help to recognize reliable precursors [5].

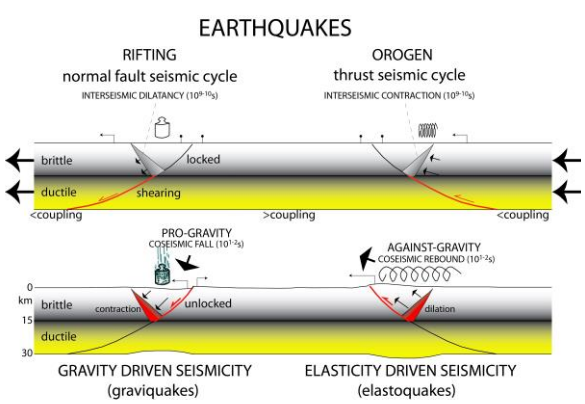

Figure 1: Simplified classification of earthquakes as a function of their energy source. Earthquakes are distinguished depending on whether they are generated by gravity in extensional tectonic settings or by elastic rebound in strike-slip and contractional tectonic environments.

Taking as case history the Italian area, we applied our model in order to calculate the potential maximum volumes that can be activated during the coseismic stage in the different tectonic settings (extensional, strike-slip and contractional), each one characterized by peculiar energy dissipation and variable volumes. As an example, in the extensional domain, the Apennines have a BDT between 10 and 18 km depth, constraining the volume of the falling hanginwall of a normal fault that may in principle be up to three times longer than the BDT depth. In the area having the largest volumes, the Apennines experienced among the world largest magnitudes normal fault-related earthquakes (M>7). The stronger earthquakes occur in areas of relative lower strain rate, where faults are more locked. Fluids flux increase, initial half-graben subsidence and related foreshocks along the antithetic dilated band formed during the interseismic period, all may represent useful earthquake precursors to be monitored.

References:

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