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New methodologies to analyse aftershocks duration in extensional and compressional tectonic settings

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Every day, moderate to large magnitude earthquakes release seismic energy stored within the Earth's crust. This energy is accumulated for tens or thousands of years, during the interseismic phase, and released instantaneously (i.e. seconds) through an earthquake (i.e. the mainshock) during the co-seismic phase. After the mainshock, the energy release continues (for months to years) during the post-seismic phase with aftershocks generally characterized by magnitudes smaller than the mainshock. Few studies were dedicated to the control of tectonic setting on the duration of aftershock sequences, although a better understanding of aftershocks decay with time is fundamental to better constrain seismic hazard during ongoing seismic sequences by predicting their duration. Typically, seismological observations indicate that, within a seismic sequence, the aftershocks decay in time follows the Omori-Utsu law and depends on several parameters peculiar of each seismogenic region (i.e. tectonic setting, stress changes along fault, structural heterogeneities, crustal rheology). However, the geological and seismotectonic parameters that control the aftershocks decay during seismic sequences are still unclear. In this work, we focused on the tectonic setting control on the aftershocks decay within seismic sequences. In particular, we analysed five aftershocks sequences within extensional settings and five within compressional environments. To determine the duration and the number of events of the selected aftershock sequences, we employed two innovative methodologies: the Tangents and the Mandelbrot methods. The first methodology allowed us to distinguish two different parts in the graphs: one indicates a non-linear increase of the cumulative number and the other one a linear increment. The first trend suggests that the seismic sequence related to the mainshock event is still active, whereas the linear increment represents the ground seismicity that affect an active seismic region. We consider the point where the tangent to the linear increment departs from the cumulative curve as indicative of the end of the aftershock sequence. The second method is based on the fractals theory and allowed us to examined faulting and fragmentation processes. The fractal geometries are related to fragmentation processes caused by earthquake nucleation and, therefore, the variation of fractal parameters can be indicative of the evolutions of the fragmentation processes along a fault system in time and space. The obtained results show that, on average and irrespective of the mainshock magnitude, aftershock sequences are longer and the number of earthquakes is greater in extensional tectonic settings than in compressional ones. We interpret this difference as related to the different type of energy dissipated during earthquakes. In detail, a joint effect of gravitational forces and pure elastic stress release governs extensional earthquakes, whereas pure elastic stress release controls compressional earthquakes. Accordingly, normal faults operate in favour of gravity, preserving inertia for a longer period and seismicity lasts until gravitational equilibrium is reached. Vice versa, thrusts act against gravity, exhaust their inertia faster and the elastic energy dissipation is buffered by the gravitational force. Hence, for seismic sequences of comparable magnitude and rheological parameters, aftershocks last longer in extensional settings because gravity favours the collapse of the hangingwall volumes.