Geophysical Research Abstracts
Vol. 13, EGU2011-6608, 2011
EGU General Assembly 2011

Scaling Relationships for Earthquake Source Parameters Down to Decametric Fracture Lengths

Aldo Zollo (1), Antonella Orefice (1), and Vincenzo Convertito (2)

(1) University of Naples Federico II, Naples, Italy (aldo.zollo@unina.it), (2) Istituto Nazionale di Geofisica, Osservatorio Vesuviano, Naples, Italy (convertito@ov.ingv.it)

During last two decades, technological and signal processing advances have largely increased the resolution power of the present day seismic networks and quality of the recordings. This allows to investigate the properties of microearthquakes source parameters at a very small scale (few tens of meters) and to gain new insights in the understanding of earthquake process similarity over a broad magnitude range.

Recent studies based on the analysis of displacement spectra and radiated seismic energy have pointed out the breakdown of self-similarity at M 3, which causes either the static stress drop and/or the 'apparent' stress to decrease with the earthquake size. This effect has been interpreted either in terms of source or local attenuation effects. However, one major issue to be dealt with the accurate estimation of source parameters from microearthquakes spectra is the adequate correction of observed ground motion for path attenuation, site response effects and frequency band-limitation when seismic energy is the physical observable of concern.

In this study we use a parametric approach, based on a physical description of the different effects which modify the signal radiated by seismic sources, and using observations in frequency domain to estimate a number of model parameters accounting for source, path attenuation and site effects. It is combined with a multi-step, non-linear inversion strategy to obtain the refined measurements of source parameters of microearthquakes.

The analyzed dataset consists of very high quality microearthquakes data recorded at the dense, wide-dynamic range, seismic monitoring infrastructures recently deployed by AMRA and INGV in southern Apennines, along the complex normal fault system, which has been causative in the past centuries of frequent, moderate to large earthquakes.

We investigate the scaling relationships of source parameters both from P- and S-wave signals, in a seismic moment range spanning about four orders of magnitude, down to a very low magnitude size (Mw 0.5). A constant static stress drop / apparent stress scaling of P and S corner frequencies and seismic energies is observed down to a moment of about 10ˆ12 Nm, while a violation of self-similarity is evident for smaller events.

This is due to a saturation effect on corner frequencies at about 20-25 Hz, due to the high frequency bandwidth limitation of the seismic radiation, which is controlled by a maximum frequency, fmax , Acceleration spectra corrected for path attenuation and site transfer function, show that fmax clearly depends of the event magnitude , thus suggesting that the corner frequency saturation is related to small wavelength source complexities rather than local attenuation effect.

A similar breakdown in self-similarity at Mw about 2 is observed for seismic energies, which confirms that fmax controls both corner frequency and energy estimations. This result is also responsible for the observed change in the Mw-ML relationship at the same threshold magnitude (Mw 2). As a consequence, static stress drop (derived from corner frequency) is not independent from apparent stress (derived from squared velocity integral) as displayed by the correlation of the two quantities.

Despite the self-similarity violation, the estimated P-to-S energy ratio is consistent with the theoretical expected value, given an observed P-to-S corner frequency ratio of 1.5. Similarly, the observed ratio between apparent stress and static stress drop, which is a measure of seismic efficiency, matches well with theoretical predictions assuming the Brune(1970)' or Madariaga(1976)' models for circular fault radius.

The Irpinia fault system data are very consistent with the observations at 2.5 km depth Cajon Pass borehole seismometer (Abercrombie, 1995), both indicating a relatively low value for Savage-Wood efficiency (a factor 4-5 smaller than laboratory measurements and mining-induced earthquakes), which does not appear to depend on seismic moment on about four orders of magnitude.