ANALYSIS OF SOURCE PARAMETERS FOR BOTH NATURAL AND INDUCED SMALL SEISMICITY IN ITALY

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In this study we analyse and discuss some source parameters obtained by Full Moment Tensor (FMT) inversions of small earthquakes with ML comprised between 0.3 and 3.0 occurred in Italy. To perform the FMT inversion we use HybridMT technique (Andersen, 2001; Kwiatek et al., 2016) supported by a detailed 1D velocity model. This methodology is based on the concept that the first P-pulse area is proportional to the seismic moment. The data-input is obtained from
the vertical component from which the area of the first P-wave Ground Displacement pulse (Ω) in time domain is computed. Ω can be achieved by integrating the ground displacement pulse starting from P-wave onset time to first zero crossing after the maximum amplitude. After a visual selection based on the signal-to-noise ratio, we filter the seismograms (2-50 Hz) and we compute the correspondent signal displacement to estimate P-wave pulse polarities and Ω for each event and for each station (at least 10) with epicentral distance comparable to the focal depth. Uncertainties of estimated FMTs are expressed by normalized root-mean-square (RMS errors) between theoretical and estimated amplitudes (Vavricuk et al., 2014). We present two different Italian case studies: (i) the microseismicity recorded in the Val d’Agri (VDA) oilfield in 2006 during some injection tests in a wastewater disposal well and (ii) aftershock recordings of “The Amatrice 2016 seismic sequence”.

(i) VDA is a Quaternary extensional basin located in the Southern Apennines characterized by a complex tectonic evolution, high seismic hazard and significant hydrocarbon exploitation. The basin hosts the largest onshore oilfield in Europe that produces oil and associated gas from low-porosity, fractured Cretaceous limestone. Wastewater associated to hydrocarbon production is reinjected into the Costa Molina 2 high-rate well (CM2) into an unproductive marginal portion of the carbonate reservoir at 2890-3096 m depth (b.s.l.). Initial injection tests were performed with variable duration (from 4 to 32 hr) and hourly injection rate of 38 m$^3$/hr. During the tests a maximum well-head pressure of 101 bar was measured. The testing data-set includes swarm-type induced microseismicity (69 earthquakes with 0.3 ≤ ML ≤ 1.8) recorded during the initial daily injection tests (between 2-12 June 2006) by a high-performance local network run by INGV (Mc 0.4, 23 stations) and accurately located by high-resolution local earthquake tomography (Improta et al., 2017). We obtain that CM2 shows significant source Non Double Couple components (80%) in which 25 < %ISO < 33; Almost all positive %ISO and %CLVD correlate the injection pressure peaks; Maximum %ISO, %CLVD and Mw correlate the pressure peak related to the last 2-3 days of injection test (Roselli et al., 2018). We found that orientation of the P and T axes of the source mechanisms estimated by the FMT inversion is in close agreement with local stress field (i.e. $S_{\text{min}}$ directions) inferred from borehole breakout data from nearby wells and S-wave splitting analysis carried out on recordings of the injection induced events (Pastori et al., 2009; Improta et al., 2015; Improta et al., 2017).

(ii) “The Amatrice 2016 seismic sequence” is characterized by an Mw 6.0 mainshock that occurred close to the towns of Accumoli and Amatrice at 1:36 a.m. (UTC) of August 24th 2016 and it is still ongoing. In 20 months activity, 63905 recorded earthquakes are spatially elongated NW-SE, the aftershocks are mainly concentrated between 1 and 10 km of depth with minimum and maximum magnitude ranging from Mw 0.1 to 6.5, respectively. This study area is characterized by a complex geological and structural setting derived by multi-phased contractional and extensional deformation began in the Early Tertiary. In detail, the epicentral area is located in the central sector of Apennine chain characterized by several NNW-SSE oriented Quaternary fault systems and compressional fronts. Nowadays stress indicators (such as borehole breakouts, anisotropic parameters, earthquake focal mechanisms and active faults) point out that the axial part of the Apennine belt is characterized by a general extension about ENE-WSW oriented. We define the possible correlations between Shear Wave Splitting (SWS; Crampin S., 2003) in terms of the fast direction polarization and delay time and moment tensor parameters in terms of P-T-B axes directions, during the seismic sequence (Pastori and Roselli, 2018). To perform the preliminary comparison, we extract 30 earthquakes ($M_L = 3.0 \pm 0.2$; depth < 20 km) coming from a biggest dataset proposed by Pastori et al. (2018). These events, occurred during the first 6 months, are recorded by 38 seismic stations (permanent and temporary) both run by INGV. The temporary network is installed by SISMIKO working group (2016) soon after the 24th August 2016 mainshock within the
epicentral area. For both methods we use the hypocentral locations obtained by non-linear inversion proposed by Michele et al. (2016) and Chiaraluce eet al. (2017). We compare both single and averaged spatial results and we observe a general agreement considering that the structural setting could affect the SWS results. Moreover, the temporal results suggest a very good agreement between FMT and SWS and their bi-directional trend: NW-SE and NE-SW. The great variability is visible especially in correspondence of the main earthquakes occurrence to confirm changes in the local active stress field.

References
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