The Correlation Between Historical and Instrumental Seismicity in the Sansepolcro Basin, Northern Apennines, Italy

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Abstract

The area investigated, the Sansepolcro basin, is characterized by the presence of important earthquakes in the past with estimated intensity even larger than IX MCS (the 1352 Monterchi earthquake, the 1389 Boccaserriola, the 1458 Citta' di Castello, the 1781 Cagliese and the 1917 Monterchi-Citerna earthquakes, CPTI Working Group, 2004) and by a surprisingly scarce instrumental seismicity compared to the adjacent areas struck by high seismicity (Castello et al., 2005; Ciaccio et al., 2006). The area north of Sansepolcro has been struck in recent years by four minor sequences, occurred between 1987 and 2001 with magnitude ranging from Ml3.0 to Mw4.7. In this work we analyse the most important earthquakes of the 20th century occurred in the Altotiberina Valley in 1917, 1918, 1919 and 1948; in particular instrumental relocation, focal mechanisms and Ms and Mw magnitude estimation are re-evaluated. The relocation of these earthquakes is particularly critical and is an important issue. An instrumental and precise location is critical for the complexity of the problems associated with the study of seismograms prior to the first half of the twentieth century and is relevant because in the surrounding regions higher seismicity is observed. Regarding this peculiarity of the area, it's very important to detect the location of the historical earthquakes: in particular, the 1917 event is often associated to the possibility that the regional low angle Altotiberina Fault (Barchi et al., 1998) is able or not to nucleate large- or moderate-magnitude events, being historically located close to its surface (Boncio and Lavecchia, 2000).

References

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Tectonic setting and Instrumental Seismicity

The Sansepolcro basin (Figure 1) is a NW-SE elongated basin, about 10 km long and 6 km wide, presently occupied by the northernmost part of the High Tiber Valley.

The Sansepolcro basin represents the northernmost basin, located north of the Città di Castello town. It is infilled by Quaternary continental, fluvial and lacustrine sediments. Most Authors recognised that the onset and evolution of the Tiber basin was driven by a complex system of NNW-SSE striking normal faults.

The Sansepolcro basin is a region characterized by the absence of instrumental seismicity (M > 2.5) even if several historical events are recorded. On the contrary, the zone north of Sansepolcro has been site in the last years of diffuse moderate seismicity testified by four sequences from 1987 to 2001. The strongest mainshock (Md=4.3; Ml=4.4) occurred on November 26, 2001 (Figure 2), the other sequences presented mainshock of of Md=4.1, in October 1997, Md=3.7 in May 1990 and Md=3.8 in July 1987. The depth of the 2001 mainshock is localized at 8 km. The mainshock displays a normal fault mechanism with NW-SE strike, low-angle rupture plane dipping toward NE, similar to the focal mechanism of the 1997 sequence. The epicenter distribution of the 2001 sequence is very well constrained compared to the previous ones because of the larger number of station recordings available. Allthough the smaller number of stations, a SW-dipping alignment is observed for the 1997 sequence. The focal sphere of the 1987 mainshock shows a normal mechanism with an EW-strike (Ciaccio et al, 2006 and ref. therein).

These previous results will be improved with the further analysis of the 22 March 1918 and 25 October 1919 and 13 June 1948 earquakes, where only a macroseismic location and magnitude estimation are available.

Figure 1

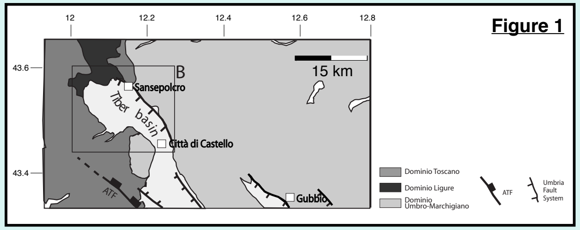
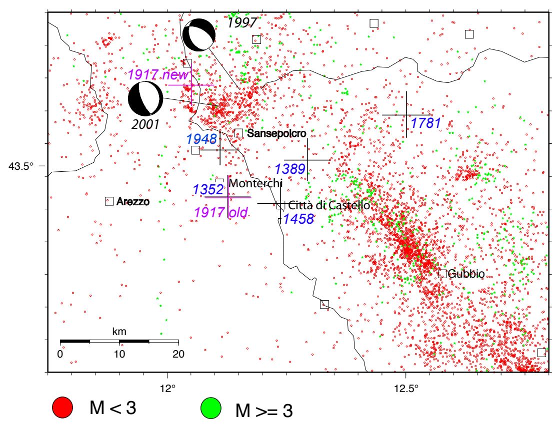


Figure 2



Moment Magnitude M_w

M_w is derived using the Brune (1970, 1971) relationship between ground displacement spectra (example on Figure 3), seismic moment M_o and corner frequency.

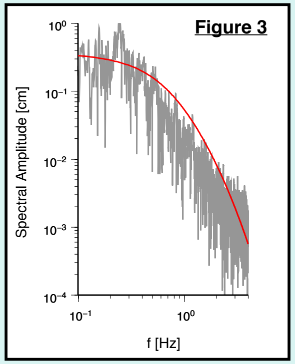
We computed the seismic moment Mo from the spectra of 5 seismograms (see table Table 1) for which the instrument calibration are available. Our Meadian and Mean show a coherent value of M_W=5.4

Table 1

Station	Component	M_o [N·m]	
GTT	NS	1.12e+17	
MNH	NS	2.26e+17	
POT	NS	1.81e+17	
UCC	NS	1.38e+17	
ZAG	WN	2.20e+17	
Mean		1.77e+17	M_w=5.4
Median		1.81e+17	M_w=5.4

$$Mw = \frac{\log M_o}{1.5} - 6.07$$

Figure 3



Moment Tensor foreward modeling

a) We generate synthetic seismograms for random Moment tensors.

b) Both observed and synthetic are bandpassed filtered in the narrow band where the historical seismographs are generally sensitive (1-15 seconds). We then consider the maximum amplitudes of P-, S- And Surfacewaves for each of the 3 components and for both synthetics and historical digitized seismograms. Synthetics are generated for different depth.

c) Compute relative amplitudes ratio between the three possible combination of the three measured amplitudes within each seismogram.

d) Add constrain of the polarities of the P-wave to constrain the directivity of the fault, sinthe amlitude waves contains only informations about the source geometry.

e) The best moment tensr has minimum variance and best polarity P-wave fit.

Discussion

i) Amplitudes are less sensitive to the crustal and mantel heterogeneities than phases, thus we do not require well calibrated earth model to generate synthetics.

ii) We do not fit absolute amplitude and phases between observed and synthetics data. Thus we do not require the knowledge of all instrument parameters of the historical seismographs, which are needed to compute the instrument response for deconvolution.

iii) Using the only relative maximal amplitude, we obtaing an unitary moment tensor (Figure 4), which seismic moment module should be derived using other methods, as shown in section above.

iv) This method shows reliable solutions also with few stations. In our case study we used only stations GTT (NS component), MNH (NS), UCC(NS/EW) and UPP(NS/EW), and the solution (Figure 5) also confirm that the 1917 earthquake should be occoured north-west with respect the previous macroseimic location.

Figure 4

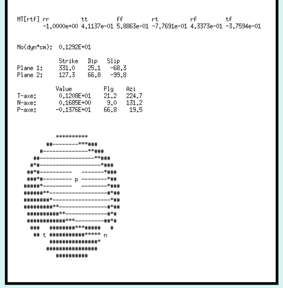
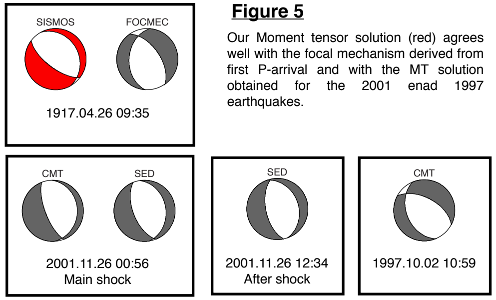


Figure 5



Our Moment tensor solution (red) agrees well with the focal mechanism derived from first P-arrival and with the MT solution obtained for the 2001 enad 1997 earthquakes.