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Orientation of seismic ruptures from P polarities and P pulse widths inversions: the Sellano (Umbria-Marche) case study

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It is well known that the fault plane solutions of earthquakes occurring in small volumes of the crust are often very different. In these cases, it is difficult to establish if these different orientations are really caused by local scale heterogeneities of the stress field or are simply an artifact of the non linear inversion techniques used to retrieve them.

From the inversion of P polarities of fifty small earthquakes occurred in a small volume below the little town of Sellano, during the 1997 Umbria-Marche (Central Italy) seismic crisis, we found a great variety of focal mechanisms solutions, with a dominant normal component. In spite of the high azimuthal coverage of the focal sphere, these solutions are poorly constrained, mainly as a consequence of the relative source to receivers position. On the first P body waves we observed significant variations of the characteristic durations with varying the source to receiver azimuth, which could be caused by directivity source effects and used to recover the fault plane orientation. To this end, two time domain techniques, which assume different source shapes (unilateral and circular), were used to infer the source and the attenuation parameters from the inversion of rise times and pulse widths data. In this way we obtained reliable estimates of the average intrinsic quality factor Qp, of the local attenuation site effects and of the source dimensions. After the correction for attenuation, by using a robust search-grid method, rise time and pulse widths were inverted to obtain the fault plane orientations. Random deviates analyses were carried out to estimate the error

on parameters and their correlation. Synthetic tests allowed us to evaluate the effect of the discrete sampling of data on the focal sphere. By comparing the fault plane solutions obtained from the inversion of P polarities with those inferred from the pulse widths inversions we were able to univocally constrain the fault plane orientation of twenty-nine events. These solutions do not align along a particular structure and do not indicate a preferential direction of fault dipping. By using a locally calibrated relationship among local magnitude and seismic moment, the stress drop $\Delta\sigma$ of each event was also estimated. We inferred a great range of variation of $\Delta\sigma$, from 1 to 100 bars. On the whole, these results, together with the results of previous investigations, led us to advance the hypothesis that the low-magnitude seismicity, in the southernmost part of the Umbria-Marche sequence, was probably controlled by local scale heterogeneities in the stress field on randomly oriented surfaces of weakness.