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Abstract title

IMAGING THE ACTIVE STRESS FIELD OF THREE SEISMOGENIC AREAS ALONG THE APENNINES AS REVEALED BY CRUSTAL ANISOTROPY

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Abstract

During the last decades, the study of seismic anisotropy has provided useful information for the interpretation and evaluation of the stress field and active crustal deformation. Seismic anisotropy can yield valuable information on upper crustal structure, fracture field, and presence of fluid-saturated rocks crossed by shear waves. Several studies worldwide demonstrate that seismic anisotropy is related to stress-aligned, filled-fluid micro-cracks (EDA model).
An automatic analysis code, “Anisomat+”, was developed, tested and improved to calculate the anisotropic parameters: fast polarization direction (φ) and delay time (∂t). Anisomat+ has been compared to other two automatic analysis codes (SPY and SHEBA) and tested on three zones of the Apennines (Val d’Agri, Tiber Valley and L’Aquila surroundings).
The anisotropic parameters, resulting from the automatic computation, have been interpreted to determine the fracture field geometries; for each area, we defined the dominant fast direction and the intensity of the anisotropy, interpreting these results in the light of the geological and structural setting and of two anisotropic interpretative models, proposed in the literature. In the first one, proposed by Zinke and Zoback, the local stress field and cracks are aligned by tectonics phases and are not necessarily related to the presently active stress field. Therefore the anisotropic parameters variations are only space-dependent.
In the second, EDA model, and its development in the APE model fluid-filled micro-cracks are aligned or ‘opened’ by the active stress field and the variation of the stress field might be related to the evolution of the pore pressure in time; therefore in this case the variation of the anisotropic parameters are both space- and time- dependent.
We recognized that the average of fast directions, in the three selected areas, are oriented NW-SE, in agreement with the orientation of the active stress field, as suggested by the EDA model, but also, by the proposed by Zinke and Zoback model; in fact, NW-SE direction corresponds also to the strike of the main fault structures in the three study regions. The mean values of the magnitude of the normalized delay time range from 0.005 s/km to 0.007 s/km and to 0.009 s/km, respectively for the L'Aquila (AQU) area, the High Tiber Valley (ATF) and the Val d'Agri (VA), suggesting a 3-4% of crustal anisotropy.
In each area are also examined the spatial and temporal distribution of anisotropic parameters, which lead to some innovative observations, listed below.
1) The higher values of normalized delay times have been observed in those zones where most of the seismic events occur. This aspect was further investigated, by evaluating the average seismic rate, in a time period, between years 2005 and 2010, longer than the lapse of time, analyzed in the anisotropic studies. This comparison has highlighted that the value of the normalised delay time is larger where the seismicity rate is higher.
2) In the Alto Tiberina Fault area the higher values of normalised delay time are not only related to the presence of a high seismicity rate but also to the presence of a tectonically doubled carbonate succession. Therefore, also the lithology, plays a important role in hosting and preserving the micro-fracture network responsible for the anisotropic field.
3) The observed temporal variations of anisotropic parameters, have been observed and related to the fluctuation of pore fluid pressure at depth possibly induced by different mechanisms in the different regions, for instance, changes in the water table level in Val D’Agri, occurrence of the April 6th Mw=6.1 earthquake in L’Aquila.

Since these variations have been recognized, it is possible to affirm that the models that better fit the results, both in term of fast directions and of delay times, seems to be EDA and APE models.

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