Stress in the Italian Peninsula: a new stress map

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Stress magnitudes

This smoothed stress map, constructed using the best active stress indicators, highlights the main stress orientations and removes local perturbations within the observed stress fields. We applied a smoothing procedure due to Müller et al. (2000). The algorithm first places a regular grid over the study area, then calculates stress orientations for each grid point by considering data within a certain radius around the grid point itself. The data are weighted by their previously attributed quality and by the distance from the grid point. We have integrated our data set with part of the World Stress Map database taking into account 921 3-D directions (only A, B and C quality). 382 from our data set and 519 from the World Stress Map database 2011 release for regime around Italy. In the figure we used a "search radius" value of 90 km, a degree of smoothing equal to 1 and only grid values with at least one data point of A or B quality (or two quality C data) inside the area defined by the "search radius".

Introduction

Stress map of Italy

This map shows the seismicity distribution of M>3 earthquakes for the period 1983-2003 and the Centroid Moment Tensor fault plane solutions for M>5 (from INGV and CMT catalog).


Seismicity and focal mechanisms

The present-day stress map of Italy (Montone et al., 2004) consists of 368 data of reliable quality according to the ranking of World Stress Map Project, mainly from fault plane solutions (185) and borehole breakout (183). The data show a compressive tectonic regime in the northern Apennines from, from the Po Plain to the Adriatic offshore and along the southern Tyrrenian Sea, north of Sicily. In the Alps both compressive and transcurrent regimes are observed. Our data also confirm the whole Apenninic belt and the Calabrian arc are extending. Along the central Adriatic coast changes from one stress regime to another are shown by abrupt variations in the principal horizontal directions. Other more gentle stress rotations, as for instance the southern Apennine to the Calabrian arc, or along the northern Apennine, follow the curvature of the areas and are not associated to a stress regimes variation.

Stress directions and regimes

We estimated the stress regime in 20 boreholes from the comparison of Shmin direction and the physical properties of the rocks. Assuming: (A) one of the principal stress is vertical, (B) the state of stress is in the limit of the frictional equilibrium on pre-existing optimally oriented faults, and (C) the pore pressure is hydrostatic and equals the fluid pressure in the well, from rock strength and density, we can calculate the critical value of the maximum horizontal stress (Shmax) for which the effective tangential stress at the borehole wall overcomes the rock strength and breakouts can develop. Since we can calculate a reasonable value of stress, equal to the weight of overburden, we can determine the three principal stress for each stress regime. Then, comparing the theoretical stress distributions with breakout occurrence, it is possible to infer the stress regime. We investigated boreholes, up to 6 km deep, located in different tectonic environments and characterized by data quality of good quality (A, B and C), according to World Stress Map quality ranking system.

Regime from borehole breakouts

We computed Skirki taking into account the range between Cg (seismic compressive strength) and Cg (biastial compressive strength) and 30% of error on both values. Whenever the estimated maximum horizontal stress (Shmax) overcomes Skirki we should observe borehole breakouts. Therefore, comparison of stress occurrence along the well with the principal stress magnitudes and the different Skirki range for each stress regime, we can identify the most likely regime for the observed breakouts.

Leak-off tests (LOTs) are open-hole micro-fractures that are run as a safety measure to assess the level of fluid pressure that a well can sustain before its walls fracture. Leak-off pressure can be considered broadly equivalent to the minimum principal stress (shmin). In this study the leak-off tests were used as a safety measure to assess the level of fluid pressure that a well can sustain before its walls fracture.

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Stress data in Italy, stress map in Italy, geological structures, rock stress, Italian Seismology, active stress, geological structures.