The Pollino seismic sequence: shear wave splitting, fracture field and active stress [poster]

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THE POLLINO SEISMIC SEQUENCE: SHEAR WAVE SPLITTING, FRACTURE FIELD AND ACTIVE STRESS

Poster

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Abstract

In the years between 2002 and 2010 in the Apennine-Calabria boundary, in the Pollino area, a long seismic sequence took place. The area is subject to Northeast-Southwest extension, which results in a complex system of normal faults striking Northwest-Southeast, nearly parallel to the Apennine mountain range.

The seismic sequence includes more than 6500 earthquakes in the Pollino region, the maximum magnitude recorded is M=5.0 and it happened in October 2002. After about two years of ongoing activity, the peculiar temporal evolution of the seismic sequence allows to catalogue it as a swarm. Here we describe the main seismological characteristics of this seismic sequence and characterize the fracture field of the region. We analyzed thousands of waveforms, deriving anisotropic parameters in the crust. These parameters yield clues and insights that may help understanding the physical mechanisms behind the seismic events.

Since the late 1950s-early 1960s earthquake swarm started developing the hypothesis that included variations of the elastic properties of the Earth crust and the state of stress and its evolution prior to the occurrence of a large earthquake. Among the others the theory of the elasticity when there is no stress to elastic stress gradients forming micro-cracks, that the rock itself increases its volume, the internal or the fault rock, fluid saturation and joint pressure play an important role in earthquake nucleation, by modulating the effective stress. Thus, measuring the variations of wave speed and of anisotropic parameter in time can be highly informative on how the stress leads to a major fault failure.

A systematical look at seismic wave propagation properties to possibly reveal short-term variations in the elastic properties of the Earth crust. Active fault areas, tectonic stress variation influences fracture field orientation and field migration processes, whose evolution with time can be monitored through the measurement of the anisotropic parameters. Through the study of a wave anisotropy, it is therefore potentially possible to measure the presence, migration and state of the fault in the rock, thus providing a valuable route to understanding the seismogenic phenomena and their precursors.

Shear wave splitting is the clearest evidence of seismic anisotropy. In fact, when a seismic wave travels into an anisotropic medium, its energy is split into two components with orthogonal polarization direction that travel at different velocities. The polarization direction of the fastest wave is defined as fast direction and the lag of the slower wave is the delay time. In the crust, preferentially aligned joints or microcracks, layered bedding in sedimentary formations, or highly foliated metamorphic rocks cause anisotropy. To understand how the anisotropic parameters vary spatially and temporally, we analyzed waveforms recorded at permanent and temporary stations held by Istituto Nazionale di Geofisica e Vulcanologia.

Four-stations (MMN, T075, T072 and T0752) have the correct positions with respect to the hypocenters of the seismicity to evaluate shear wave splitting parameters; the incidence angle of the seismic rays should be smaller than 55°. Three out of these four were installed after the occurrence of the M5.0 event at the end of October 2002. MMN station instead has a very large number of measurement of shear wave splitting for the whole analyzed period (October 2002-March 2007). The predominant fast direction is coherent with the stress field in the area being parallel to the NE-SW trend. But is also parallel to the main fault structure of the area leaving the ambiguity on the possible source of seismic anisotropy. The delay time values are higher in the northwest-southwest direction.

Seismicity

Geological Setting

The study area, near the Pollino massif in SW-central Italy, is located in the Apennine-Calabria boundary. Several active faults and normal faults striking NW-SE have marked the geological evolution of the area. In the last 10 years, a seismic sequence took place around the Pollino area, the last event of notable size occurred in 1980.

Fast Polarization Direction

Spatial Results

Seismic stations, seismically constrained using MMN stations between 2002 and 2009 in the Pollino area. The hypocenter locations were projected on a map of the Pollino area and on a cross-section cut at 30 km depth to understand the tectonic setting of the area.

Delay Time

PAST POLARIZATION RESULTS - The large data sets and green curve show that at the top of the map are represented the forward plate motion and in the lower part the reverse motion. Fast directions are observed in a region of about 40 km. The fast directions are also consistent with the fast direction observed in the same area using a different technique (Podvin, 2008). The northern part of the study area can be considered an active tectonic setting. The southern part of the study area is an active tectonic setting.

Temporal Results

The temporal evolution of the seismic activity during the period 2002-2010. The seismic activity is characterized by a decrease in the activities during the first year and an increase in the activities during the second year. The temporal evolution is also characterized by a decrease in the magnitude of the events during the first year and an increase in the magnitude of the events during the second year.