SEISMIC ACTIVITY IN THE POLLINO REGION (BASILICATA-CALABRIA BORDER)

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Introduction. The Pollino region and the whole Calabria-Lucania border are known for the absence of destructive (M>6) historical earthquakes. This lack of historical seismicity is noticeable in the analysis of Southern Apennines and Calabria earthquake history (Rovida *et al.,* 2011). At the same time, paleoseismological studies found evidence for significant active faulting (Cinti *et al.,* 1997; Michetti *et al.,* 1997) pointing to the Pollino area as a seismic gap. Instrumental seismicity in the region is characterized by the occurrence of seismic sequences, one of the most significant in the last decades is the Mercure seismic sequence, Mw 5.6 in September 1998 (Brozzetti *et al.,* 2008). For this reason, the sequence started in 2010 raised a big concern in the population and local authorities. INGV is following the evolution of the sequence since its beginning, in March 2010, increasing the seismic monitoring and planning several activities and projects. The area was proposed by INGV to DPC (Dipartimento di Protezione Civile nazionale) for inclusion in the projects to be carried out in the present INGV-DPC agreement. This project has just started and will try to provide better constraints to the active tectonics and fault identification of the region. In this paper we describe what INGV is doing to understand better the tectonics of the region using microseismicity, and try to offer some cue to the discussion about the seismogenic faults in the area.

Historical earthquakes. Earthquakes reported in the historical catalogues for this area are not very strong. For this reason, in the 1984 seismic hazard map of Italy and even in the proposal of 1998, the region had hazard values lower than the northern and the southern areas. However, the more recent seismic zonation ZS9 (Meletti *et al.*, 2008) and the 2003-2004 seismic hazard map identifies the whole Lucania-Calabria Apennines as a homogeneous region capable of large earthquakes and hence with high seismic hazard (http://zonesismiche.mi.ingv.it).

The Parametric Catalogue of Italian earthquakes (CPTI11, Rovida *et al.*, 2011), shows very well the lack of strong earthquakes in the region, contrary to the southern Apennines and the Calabria area. In the former, there is clear evidence of large earthquakes in the Campania-Basilicata area, mainly the M~7 earthquake in 1857. To the south, several strong earthquakes hit the Sila region and

Tab.1 - Earthquakes in the Pollino region with magnitude larger than 3.

Event date and time	latitude	longitude	depth	Ml
2012-09-14 03:50:11.000	39.896	16.019	7.6	3.7
2012-09-07 12:40:51.000	39.877	16.028	8.5	3.4
2012-09-01 14:02:45.000	39.887	16.004	7.8	3.4
2012-08-26 15:44:38.000	39.877	16.206	6.8	3.0
2012-08-19 17:45:08.000	39.875	16.005	5.0	3.7
2012-05-28 01:32:10.000	39.906	16.094	8.0	3.2
2012-05-28 01:06:27.000	39.859	16.118	3.0	4.3
2011-12-24 20:17:50.360	39.920	16.023	8.1	3.3
2011-12-02 21:25:38.240	39.910	15.997	8.0	3.2
2011-12-01 14:01:20.020	39.933	15.998	9.9	3.3
2011-11-23 14:12:33.590	39.912	16.019	7.5	3.6
2010-11-09 08:43:19.890	40.048	15.934	10.4	3.7
2010-03-25 17:30:17.900	40.028	15.857	7.8	3.2

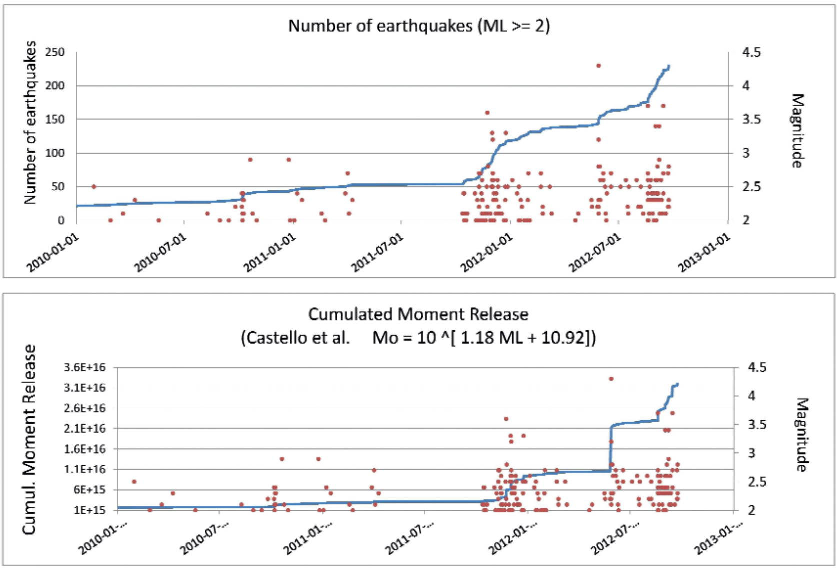

Fig. 1 - a) Number of events with magnitude (ML) equal to or larger than 2 in the Pollino area since January 2010; b) Cumulated moment release in the same region and in the same period.

the whole Calabrian territory and coasts. Around the Basilicata-Calabria border, a few earthquakes with magnitude probably less than 6 affected the area, including one in 1708 and the Mw5.6 “Mercure” event in 1998 (Brozzetti *et al.*, 2008).

Recent seismic activity. Starting from the beginning of 2010 the Pollino area has been affected by intense seismic activity (April 2010, October 2010, November 2011 February 2012, May 2012 and September 2012) interspersed with periods of relative quiescence. At the time we write (September 23) there are still several earthquakes each day located by the national seismic network.

In the two last year we recorded about 2,000 earthquakes in the area (Iside, http://iside.rm.ingv.it; Mele *et al.* 2011), but only 13 with magnitude (M_L) larger than 3 (Fig. 1, Tab. 1).

In the following we briefly describe the efforts of INGV in improving the seismic monitoring of the area in the last year and the trends of the seismicity recorded. As known, all the data recorded by the improved national seismic network and processed, both during real time analysis and revised bulletins, are available to the public and the scientific community on iside.rm.ingv.it.

The seismic monitoring of the area in the last year. After the increasing of seismic moment release in November 2011 the Centro Nazionale Terremoti of INGV, in collaboration with the Dipartimento di Fisica dell’Università della Calabria improved the seismic monitoring network in the Pollino region to lower the detection threshold of the network and to improve the hypocentral locations of small earthquakes. One permanent station of the Italian seismic network was installed to the south (CET) and three real time (UMTS transmission) temporary stations were deployed (Fig. 2): T0711,T0712 and T0715. The T0711 was moved to T0716 after one month for transmission problems in the former site. At the end of May 2012, after the occurrence of the M_L 4.3 event, two other temporary stations transmitting in real time to the INGV monitoring room were deployed : T0701 and T0702 (Fig. 2).

The 2011-2012 seismicity. The strongest event in the Pollino region during the last year occurred on May 28th 2012 with M_L 4.3 and a moment tensor solution indicating extensional faulting on NNW trending planes (Fig. 2); very similar time domain moment tensors (TDMT) were evaluated for the 23 November 2011, the 19 August 2012 and the 14 September 2012 events. All these focal mechanisms identify a crustal extension in the NE-SW direction with fault planes having NNW-SSE strikes (see http://cnt.rm.ingv.it/tdmt.html).

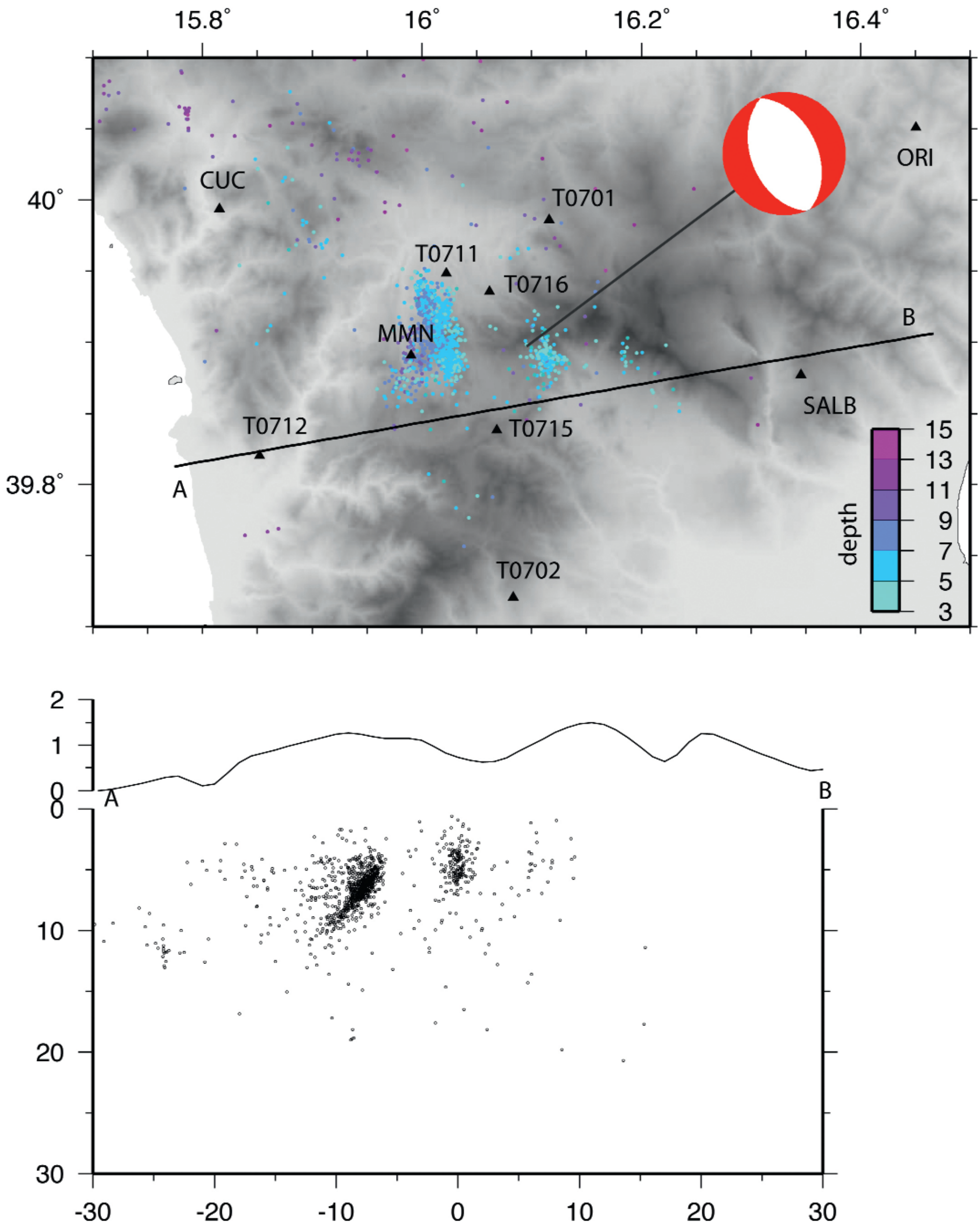

Fig. 2 - a) Map of the seismic network and of the seismic sequence in the Pollino region. Black triangles are the seismic stations; colored circles represent the seismicity; the line is the trace of the vertical section below; b) Vertical cross-section showing the trend of hypocenters at depth (see the text). c) Lower right: Moment tensor solution for the largest event recorded in the last year. Moment tensor solution parameters are: Strike=159 ; 335 - Rake =-87 ; -93 - Dip =45 ; 45 - Depth = 3km - Mo =3.33e+22 - Mw =4.3.

The hypocentral locations shown in Fig. 2 are obtained starting from the arrival times of the INGV monitoring room and bulletin, and were relocated using the HypoDD location code (Waldhauser and Ellsworth, 2000). The hypocenters are mostly located between 2 and 10 km depth,

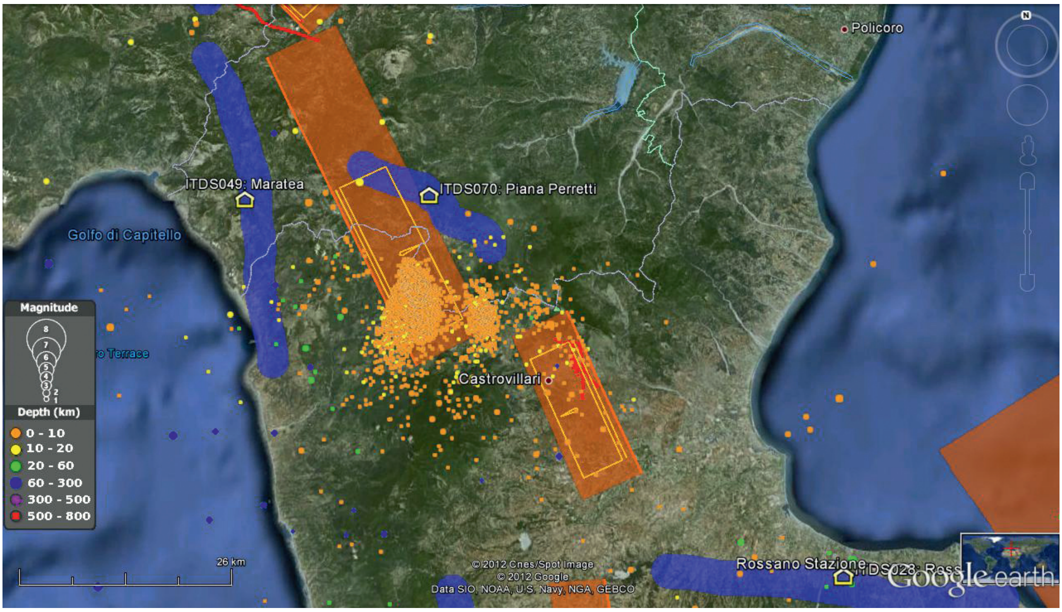

Fig. 3 - Comparison between recent seismicity (2010-2012) and seismogenic sources in the DISS database.

and show two main clusters: a western one, which includes most of the seismicity, shows a NNW-SSE elongation and in vertical cross section depicts a fault plane dipping toward WSW, with a hint of listric geometry. The eastern cluster of seismicity does not clearly identify a fault plane in map view and in cross section. However, it is relevant that the M_L 4.3 event is located in this eastern cluster and its moment tensor solution (Fig. 2) shows a NNW-SSE normal fault as well.

Active faults. The geometry depicted by the microseismicity and shown in Fig. 2 can help to identify major active faults. This is particularly important in areas where no large earthquakes have been recorded instrumentally, nor are reported in historical catalogues. We have seen that the trend of the relocated seismicity and the fault plane solutions identified by the TDMT's are consistent with normal faults trending ~N20W and dipping at about 45° to the SW. No inference can be done at the moment about the relationship between the two clusters, but hypocentral distribution and focal mechanisms suggest that they are characterized by similar geometry and kinematics.

Comparing these data with the seismogenic sources reported in the DISS (DISS Working Group, 2010; Basili *et al.*, 2008) we find that none of the proposed faults fits well the geometry suggested by the microearthquakes (Fig. 3). According to DISS, a major fault structure to the north is the "Rimendiello-Mormanno" fault system, constrained by geological data. The trend of this composite source is roughly consistent with the trend of the recent seismicity but the dip is to the northeast. More to the south, the Pollino source (Castrovillari fault according to Cinti *et al.*, 1997) has a comparable trend (N20W) and a western dip, as the 2010-2012 seismicity, but its northern edge of the Castrovillari fault corresponds with the southernmost epicenters (Fig. 5). Lastly, the Piana Perretti fault (Brozzetti *et al.*, 2009) could be connected to the microseismicity at depth, but its trend is rotated by about 30°- 40° CCW with respect to the recent seismicity trend.

References

Basili R., G. Valensise, P. Vannoli, P. Burrato, U. Fracassi, S. Mariano, M.M. Tiberti, E. Boschi (2008), The Database of Individual Seismogenic Sources (DISS), version 3: summarizing 20 years of research on Italy's earthquake geology, Tectonophysics, doi:10.1016/j.tecto.2007.04.014

Brozzetti F., G. Lavecchia, G. Mancini, G. Milana, M. Cardinali (2008). Analysis of the 9 September 1998 Mw 5.6 Mercure earthquake sequence (Southern Apennines, Italy): A multidisciplinary approach, Tectonophysics, DOI:10.1016/j.tecto.2008.12.007

Cinti F.R., Cucci L., Pantosti D., D'addezio G. & Meghraoui M., (1997) "A major seismogenic fault in a ""silent area"": the

Castrovillari fault (southern Apennines, Italy).” Geophys. J. Int., 130, 595-605.

DISS Working Group (2010). Database of Individual Seismogenic Sources (DISS), Version 3.1.1: A compilation of potential sources for earthquakes larger than M 5.5 in Italy and surrounding areas. http://diss.rm.ingv.it/diss/, © INGV 2010 - Istituto Nazionale di Geofisica e Vulcanologia - All rights reserved.

Mele, F., A. Basili, A. Bono, V. Lauciani, A. Mandiello, C. Marcocci, S. Mazza, S. Pintore, M. Quintiliani, L. Scognamiglio e G. Selvaggi (2011). La base di dati ISIDe: stato attuale e possibili sviluppi, in Cattaneo M. e Moretti M., eds. Riassunti estesi I° Workshop Tecnico “Monitoraggio sismico del territorio nazionale: stato dell’arte e sviluppo delle reti di monitoraggio sismico” Roma 20 | 21 dicembre 2010. Miscellanea INGV, N°10; 128-130. ISSN 2039-6651.

Meletti, C., F. Galadini, G. Valensise, M. Stucchi, R. Basili, S. Barba, G. Vannucci, E. Boschi (2008). A seismic source zone model for the seismic hazard assessment of the Italian territory. Tectonophysics, 450 (2008) 85–108, doi:10.1016/j.tecto.2008.01.003

Michetti, A., L. Ferreli, L. Serva, E. Vittori, Geological evidence for strong historical earthquake in an aseismic region: the Pollino case (southern Italy), J. Geodynamics, 24, 67-86, 1997.

Rovida, A., R. Camassi, P. Gasperini e M. Stucchi (a cura di), 2011. CPTI11, la versione 2011 del Catalogo Parametrico dei Terremoti Italiani. Milano, Bologna, http://emidius.mi.ingv.it/CPTI

Waldhauser F. and W.L. Ellsworth, A double-difference earthquake location algorithm: Method and application to the northern Hayward fault, Bull. Seism. Soc. Am., 90, 1353-1368, 2000.

NEW MORPHOTECTONIC CONSTRAINTS ON THE ACTIVE FAULT SYSTEM OF MONTE MARZANO (SOUTHERN APENNINES)

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Introduction. The aim of this study is that of investigating, by means of morphotectonic analysis, active fault zones in the Monte Marzano area. The study area is located in the axial portion of the southern Apennines mountain belt (Fig. 1) and falls within the epicentral area of some of the strongest historical earthquakes of southern Italy, *i.e*. those with intensity I ≥ X MCS that occurred in 989, 1694, 1930, 1962 and 1980 (e.g., Porfido *et al.*, 2002; Pondrelli *et al.*, 2006; Locati *et al.*, 2011). In the last 30 years, a large amount of studies have provided constraints to seismicity and tectonics active in the epicentral area of the 23 November 1980, Ms=6.9 Irpinia earthquake, the strongest and most destructive (I_0=X MCS) seismic event of the last decennia in southern Italy. By such studies, it appears that both the earthquake complexity, and the historical and present-day seismicity, represent the response to a complex active tectonics scenario, and suggest the existence of an active graben-like structure defined by at least two antithetic major faults. However, still debated and, in some instances, controversial, are the pattern, distribution and localization of active structures, with major implications on both cumulative deformation rates and related hazard.

Detailed analysis of the topography of the Monte Marzano massif and surrounding area, based on interpretation of 1:25,000 and 1:5,000 maps and of a detailed DTM, integrated by morpho-stratigraphical reconstructions and by age constraints on the Quaternary deposits, allowed us to identify normal faults active during the late Quaternary, and to unravel the faulting chronology.

Geological framework. The study area is dominated by the Monte Marzano morphostructural high, with a maximum elevation of 1579 m (Fig. 2). The Monte Marzano massif is composed of a more than 2000 m thick pile of slope facies limestones and dolostones, spanning in age from the Late Triassic to the Early Miocene (ISPRA, 2011). The carbonates of the Monte Marzano massif, as well as the platform facies ones forming the backbone of the Monti Picentini and Monti Alburni massifs (located to the W and S of Monte Marzano, respectively), and of minor ridges interposed between the different massifs, are related to the so-called Apennine Platform unit (Fig. 1). The carbonate unit is tectonically underlain by the Lagonegro Basin strata (cropping out to the N of Monte Marzano), and tectonically overlain by the so-called Parasicilide unit, which represents the deformed distal portion of the Apulian continental palaeomargin (Ciarcia *et al.*, 2009). The thrust pile, represented by the Parasicilide unit, the Apennine Platform carbonates, and the Lagonegro Basin strata (e.g., Mazzoli *et al.*, 2008, and references therein) is unconformably overlain by Late Miocene wedge-top basin deposits (sandstones and conglomerates of the Castelvetere Fm.) and