Bollettino di Geofisica Teorica ed Applicata Vol. 55, n. 3, pp. 665-682; September 2014
DOI 10.4430/bgta0115

Emergency preparedness activities performed during an evolving seismic swarm: the experience of the Pollino (southern Italy) sequence

A. Masi[1], M. Mucciarelli[1,2], L. Chiauzzi[1], R. Camassi[3], G. Loperte[4] and G. Santarsiero[1]

[1] *School of Engineering, University of Basilicata, Potenza, Italy*
[2] *National Institute of Oceanography and Experimental Geophysics, Trieste, Italy*
[3] *National Institute of Geophysics and Volcanology, Roma, Italy*
[4] *Civil Protection Office of Basilicata Region, Potenza, Italy*

(Received: June 4, 2013; accepted: August 19, 2013)

ABSTRACT Since October 2010, a seismic swarm is affecting the Pollino mountain range (Basilicata and Calabria regions, southern Italy). While writing this paper the sequence is still ongoing, with more than 600 earthquakes perceived by the population having local magnitudes $M_L > 2.0$. The population main fear is the risk that a destructive event could follow the seismic swarm as it occurred at L'Aquila (central Italy) in 2009. Being not possible to predict the evolution of the sequence, the Civil Protection at national and regional level took several initiatives to help people to cope with the ongoing swarm and to prepare to possible future large events, which are anyhow expected since the area is classified at the highest hazard levels in the official seismic zonation of Italy. On October 26, 2012, an $M_L = 5.0$ shock occurred causing slight damage and forcing some people to abandon their houses. While it is not clear if this event is going to be the highest, the sequence is still continuing and the preparedness activities switched to emergency activities. Accounting for the interaction between risk communication, risk perception, emergency preparedness and management, the analysis and discussion of pros and cons of the actions taken to enhance social capacity are presented and discussed.

Key words: earthquake, seismic swarm, risk governance, emergency preparedness, risk communication.

1. Introduction

A suite of preventive actions can be carried out to mitigate natural risks working both to reduce the territorial vulnerability (technical actions) with respect to the specific natural hazard at hand, and to enhance the social capacity (cultural actions) of the involved community (people, authorities, professionals, etc). While the concept of vulnerability is largely established in the scientific community dealing with risk mitigation, this is not the case for the concept of social capacity. On this subject, an extensive discussion can be found in Kuhlicke and Steinführer (2010), where the following general definition is provided: *"By social capacity we mean all the resources available at various levels (e.g., individuals, organizations, communities) that can be used to anticipate, respond to, cope with, recover from and adapt to external stressors (e.g., a hazardous event). These resources include skills, knowledge, social networks as well as* *institutions, structures and knowledge of how to elicit and use them".*

Even though the vulnerability reduction remains the main objective to be pursued in an effective policy of risk mitigation, building social capacity helps to increase the risk perception and awareness of people, thus their capacity to adapt to and cope with natural hazards. Seismic risk perception, governance and communication are worldwide a highly topical issue and even more they will be in the future also as a consequence of what happened in the pre- and post-event emergency management phases of L'Aquila (central Italy) 2009 earthquake. After that earthquake, another strong seismic sequence, initiated on May 20, 2012, affected the Italian territory damaging many towns in Emilia region (northern Italy). It caused 27 fatalities and huge damage especially in the industrial facilities.

Furthermore, since October 2010 a seismic swarm is affecting the Pollino mountain range, at the border between Basilicata and Calabria regions, southern Italy. With respect to Basilicata region, the area mainly affected by the seismic sequence includes 15 municipalities, with a total population of about 51,000 inhabitants (ISTAT, 2011). According to the current seismic hazard map, this area belongs to the highest seismicity zone in Italy (NTC, 2008).

The continuing seismic crisis strengthened the need to set up a management strategy directed to improve the response capacity of population to possible future earthquakes. To this end, as already experienced in other countries (e.g., at Loma Prieta, 1989 California earthquake) and as suggested in some guidelines (e.g., EPA, 1998), preparedness activities take advantage of a proper risk communication strategy to the population (Blanchard-Boehm, 1998). In the Pollino area, differently to other experiences dealing with this matter whose activities were performed before or after the occurred earthquake, preparedness activities have been carried out in the midst of a seismic swarm, thus in a social condition similar to an emergency phase.

Therefore, the National Department of Civil Protection (DPC, http://www.protezionecivile.gov.it) and the Civil Protection Office of Basilicata region (http://www.protezionecivilebasilicata.it/protcivbas/home.jsp) decided to perform some actions aimed at verifying and enhancing emergency preparedness. These actions have been carried out with a constant and fruitful collaboration among the main stakeholders involved (scientific community, local and national governmental agencies, civil protection volunteers, etc.) through the following main activities:

1. cooperation between scientific community and regional and national offices of Civil Protection, especially in the relationship with local authorities (e.g., mayors, which are the first civil protection authority in their municipality);
2. interaction between DPC, National Institute of Geophysics and Volcanology (INGV, www.ingv.it) and Italian Network of University Laboratories of Seismic Engineering (ReLUIS, www.reluis.it) in order to transfer information to the population for enhancing self-protection capability and decreasing state of worry ("what to do" in case of an earthquake);
3. implementation at local scale of two communication projects, even though thought for "peace-time" and not for dissemination during a seismic crisis, that is: i) "Terremoto - Io non rischio" project devoted to the general public, and ii) "EDURISK" project for schools;
4. review of local plans of emergency, where available, using a beta-version of the Emergency Limit Condition (CLE) inspection form which is an *ad hoc* inspection form suitable to collect data for verifying and updating the content and requirements of the local plans of emergency.

In all phases, the scientific community, particularly seismologists and earthquake engineers, played an important role not only in the matters of technical substance (e.g., usability inspections) but also to define the procedures to be adopted during the preparedness activities.

2. Territorial framework

The area affected by the earthquake swarm is located on the southern part of the Apennines between the provinces of Potenza (Basilicata region) and Cosenza (Calabria region). As a consequence of the work specifically carried out by the authors, only the activities in the territory belonging to Basilicata region (Fig. 1) are presented and discussed in the present paper.

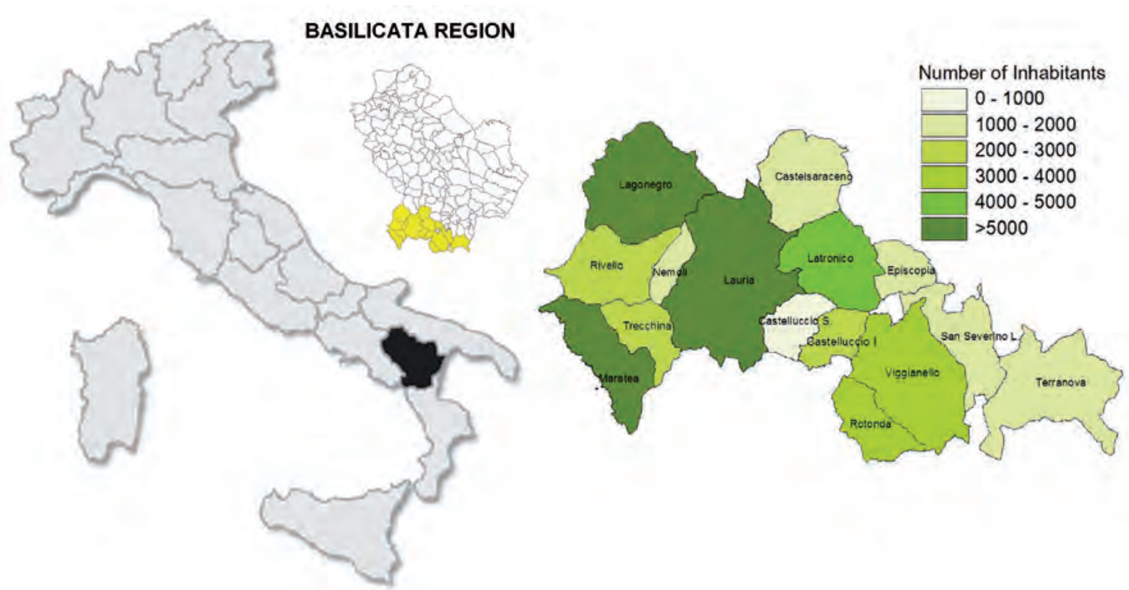


Fig. 1 - Territorial framework of the villages in Basilicata where the seismic swarm is felt, with the population living in each village (ISTAT, 2011).

The affected area in Basilicata region (Fig. 1) includes several small towns having a total population of about 51,000 inhabitants, according to the last national population census (ISTAT, 2011). The economy of the area is essentially based on agriculture and mountain tourism activities, being all the involved villages placed within the largest protected area in the European Union (Pollino national park, http://www.parcopollino.gov.it/). Especially tourism activities have been heavily affected by the negative impact of the long seismic swarm.

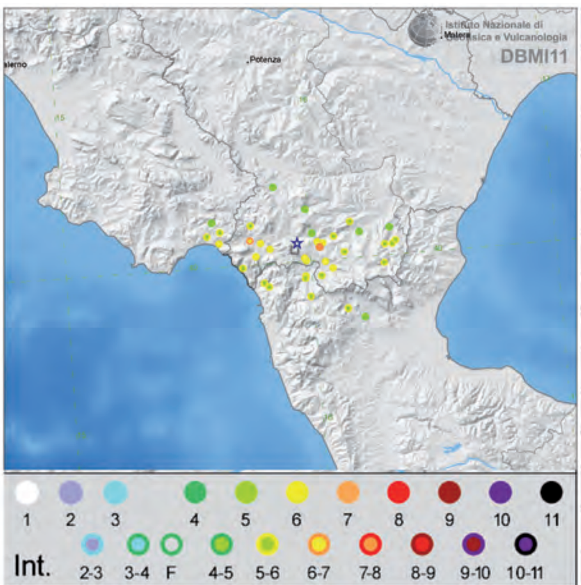
From the seismological point of view the area is located between two zones with high seismic activity, as shown by several strong earthquakes occurred in the past. To NW, the strongest earthquake occurred in 1857 (M_w 7.0, about 12,000 fatalities) and severely struck the Val d'Agri area in the Basilicata region, while on the southern part the most important earthquakes with magnitude $M_w \geq 6.5$ occurred in the Sila area (Calabria region) in 1638 and 1832.

Further, the historical seismicity of the Pollino area (see Table 1) reports several events with magnitude close to M_w 6.0, among which the 1693 (M_w 5.7) and the 1708 (M_w 5.6) earthquakes, as well as the last event with M_w 5.6 occurred on September 9, 1998. In Table 1 also some events currently not present in the Italian Earthquake Catalogue CPTI11 (Rovida *et al.*, 2011) and resulting from more recent studies (Camassi and Castelli, 2004; Castelli and Camassi, 2005; Molin *et al.*, 2008; Camassi *et al.*, 2011) are reported. Among these events, the 1559 and the March 9, 1980 earthquakes can be cited.

The 1998 event caused macroseismic intensity values up to VII degree of MCS scale, one dead, some injured and widespread damage in nine municipalities (Dolce *et al.*, 1999) of the Basilicata region (Fig. 2). As a consequence of the 1998 earthquake remembrance, some of the inhabitants in the Pollino area still suffer serious stress due to the perception of the currently occurring shocks.

Table 1 - Historical seismicity of the Pollino area also reporting some events from recent studies (I_0 is the MCS intensity at the epicentre).

Year	Month	Day	Epicentral area	I_0	M_w
1559	04	17	Morano Calabro	VII-VIII	5.6
1693	01	08	Calabria sett.	VIII	5.7
1708	01	26	Pollino	VIII-IX	5.6
1792	04	1	Viggianello	V-VI	4.3
1825	04	10	Laino Castello	VI-VII	4.5
1894	05	28	Pollino	VII	5.1
1946	04	03	M. Palanuda	n. a.	4.7
1980	03	09	Pollino	VI	4.4
1998	09	09	Calabro-Lucano's Apennine	VII	5.6



September, 9 1998 Pollino Earthquake - CPTI11 M_w 5.6		
Locality	Municipality (Province)	MCS
Perricchio	Latronico (PZ)	VII
Rivello	Rivello (PZ)	VI-VII
Castelluccio I.	Castelluccio I. (PZ)	VI
Castelluccio S.	Castelluccio S. (PZ)	VI
Gallizzi	Viggianello (PZ)	VI
Lauria	Lauria (PZ)	VI
Magnano	Latronico (PZ)	VI
Mileo	Latronico (PZ)	VI
Nemoli	Nemoli (PZ)	VI
Sapri	Sapri (SA)	VI
Trecchina	Trecchina (PZ)	VI
Viggianello	Viggianello (PZ)	VI

Fig. 2 - MCS macroseismic intensity field of the M_w 5.6 September 9, 1998 Pollino earthquake (Galli *et al.*, 2001).

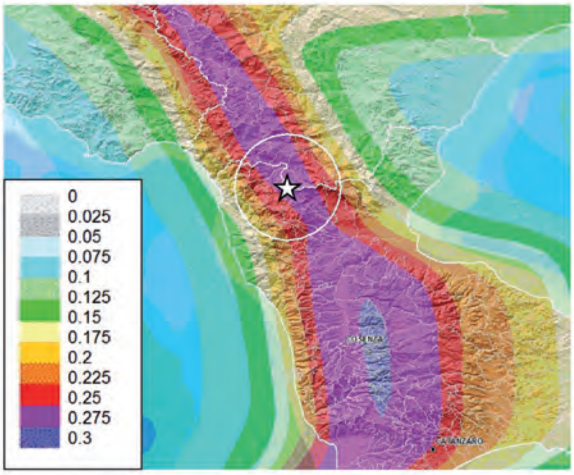


Fig. 3 - Seismic hazard map of the area (exceedance probability of 10% in 50 years, T_r = 475 years) with the epicentre of the M_L 5.0 event of October 26, 2012 (for this event see Section 5 for details).

It is worth noting that the Pollino area was marginally affected also by the November 23, 1980 Campania - Basilicata earthquake (M_w 6.9). After this strong event, all the villages, until then not classified, were classified within the national seismic map as moderate seismicity zone. Indeed, updated scientific knowledge available on the Pollino area (e.g., Meletti and Stucchi, 2011), summarized in the national seismic hazard map and finally introduced in the Italian seismic code in force from 2009 (NTC, 2008), shows that it is a very hazardous area. Particularly, expected peak ground acceleration (*PGA*) values (Fig. 3) are among the highest foreseen in Italy, being in the intervals 0.225 - 0.250 g (red area in Fig. 3) and 0.250 - 0.275 g (violet area) for a return period T_r = 475 years (i.e., 10% exceedance probability in 50 years).

Regarding the seismic vulnerability of the building stock in the affected villages, after both the 1980 Campania - Basilicata and 1998 Pollino earthquakes, substantial public funds have been invested to repair and strengthen the damaged buildings. Fig. 4 shows the distribution of the sums globally invested after the 1980 and 1998 earthquakes among the Pollino villages.

As it can be seen, after the 1980 Campania - Basilicata earthquake, about 100 millions euro have been globally invested in the Pollino area, mainly for retrofitting interventions. At present, a further strengthening program (in this case seismic upgrading interventions) with a total amount of about 200 millions of euro is being completed on the wave of the 1998 earthquake damage. Currently, complete data on the post-1998 strengthening program is not yet available,

Fig. 4 - Distribution of funding for strengthening interventions in the Pollino villages after the 1980 (on the left) and 1998 (on the right) earthquakes.

thus studies to take into account its effects on the building vulnerability of the villages under consideration are in progress.

In Samela *et al*. (2009) the vulnerability assessment of the residential buildings located in the area, including also the post-1980 retrofitting program, is carried out. The analysis of the building types' characteristics shows that the residential building stock located in the Pollino villages comprises two main building types. The first one includes non-engineered buildings located in the historical centres that have mainly unreinforced masonry structure with 2 - 3 storeys. In case they were not retrofitted, these buildings have generally high vulnerability, because of poor quality masonry walls (e.g., rubble stone) combined with deformable horizontal structures (e.g., wooden floors). Out of the historical centres the building stock is prevailingly made up of low-rise (2 - 3 storeys) reinforced concrete (RC) buildings with medium to low vulnerability. The distribution of the vulnerability classes is shown in Fig. 5. Class assignation (vulnerability decreases from class A to D) is made following the definitions of EMS-98 scale and the studies reported in Braga *et al*. (1982) and Dolce *et al*. (2003).

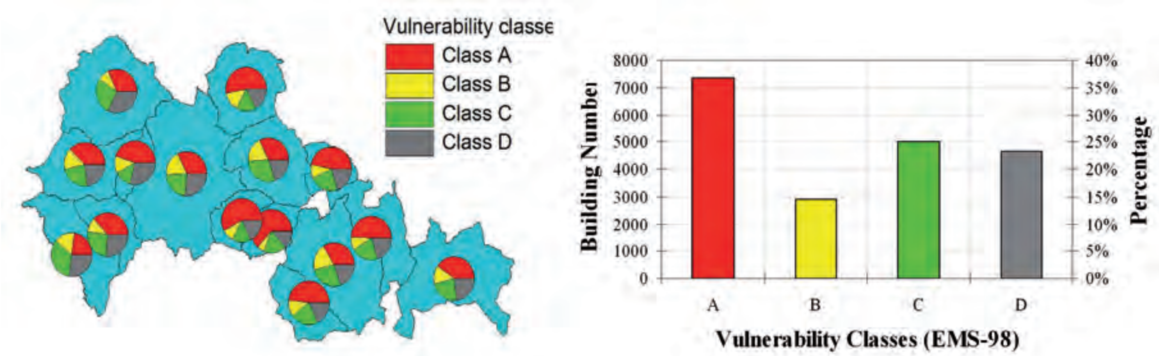


Fig. 5 - Seismic vulnerability classes of the building stock in the Pollino villages (Samela *et al*., 2009).

As can be seen in the diagram in Fig. 5 (on the right), on the whole area more than 50% of buildings have high to medium vulnerability, i.e., class A or B [EMS-98: Grünthal (1998)]. The percentage of class D (low vulnerability) is about 25%, including the buildings constructed or retrofitted after 1981, i.e., the year when all the municipalities affected by the ongoing seismic swarm were classified in moderate seismicity zone. It is worth noting that the knowledge of the vulnerability of building stock in the affected area plays an important role also in order to take measures aimed at improving the social preparedness, especially considering a possible exacerbation of the seismic crisis. In fact, in case of a widespread presence of buildings with high-medium vulnerability, emergency preparedness activities have to be planned and executed being aware that heavy and extensive damage can be expected as a consequence of the occurrence of a strong earthquake.

3. The ongoing seismic sequence

Since October 2010 a seismic swarm is affecting the Pollino mountain range. As of May 2013 the sequence is still ongoing, with more than 1,600 events with $M_L > 1.5$, and at least 600

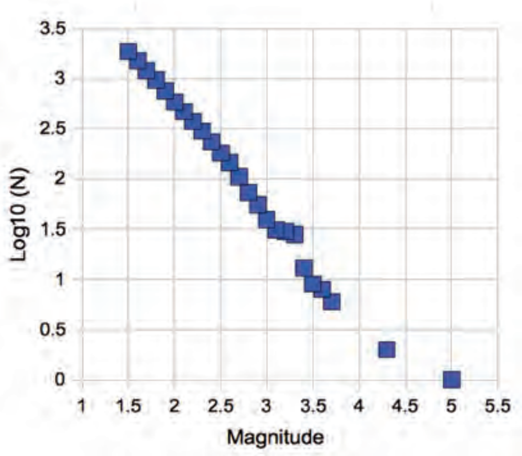


Fig. 6 - Gutenberg - Richter distribution of earthquakes for the Pollino seismic swarm (at May 2013).

with M_L > 2.0 perceived by the population. The Gutenberg-Richter distribution in Fig. 6 shows that the catalogue is complete for M_L > 1.5 and that the slope of fitting line is close to 1, thus without any particular anomaly.

The spatial distribution is in clusters (Fig. 7), with the westernmost always active during the two years, the middle one activated in May 2012, and the easternmost activated by a M_L = 3.4 shock on December 19, 2012.

Also the occurrence of the earthquakes in time is by clusters, with activity maxima whose inter-distance in time decreased by half every time for two years, until a M_L = 5.0 event took place on October 26, 2012. This behaviour is shown in Fig. 8, reporting the rate of activity expressed as the number of events with M_L > 1.5 occurring in 24 hours. Among the activity peaks in October 2010, November 2011, and June, August, September and October 2012 the elapsed time is respectively 419, 178, 83, 44 and 24 days.

4. Preparedness activities for emergency planning and management

The activities for emergency management and planning play a fundamental role in the seismic risk mitigation policy. At operating level, they are usually related to an organization process of the available resources, both material and human. Specifically, all the preparedness activities to be developed for organizing an effective emergency plan are part of an interdisciplinary approach dealing with the strategic management of processes used to protect the critical assets of an organization from hazards that can cause significant damage (Haddow *et al.*, 2010).

The setting up of preparedness activities has to identify actors, procedures and elements at risk which can assume a fundamental role during the response to extraordinary situations associated with natural events such as earthquakes. In highly developed countries like Italy, preparedness activities are (or should be) carried out in order to: i) establish the management organization required to effectively tackle post-event emergencies, ii) identify responsibilities and procedures required to protect health and safety of the affected population, and iii) establish the operational concepts and procedures associated with field response involving both national and local emergency operation centres.

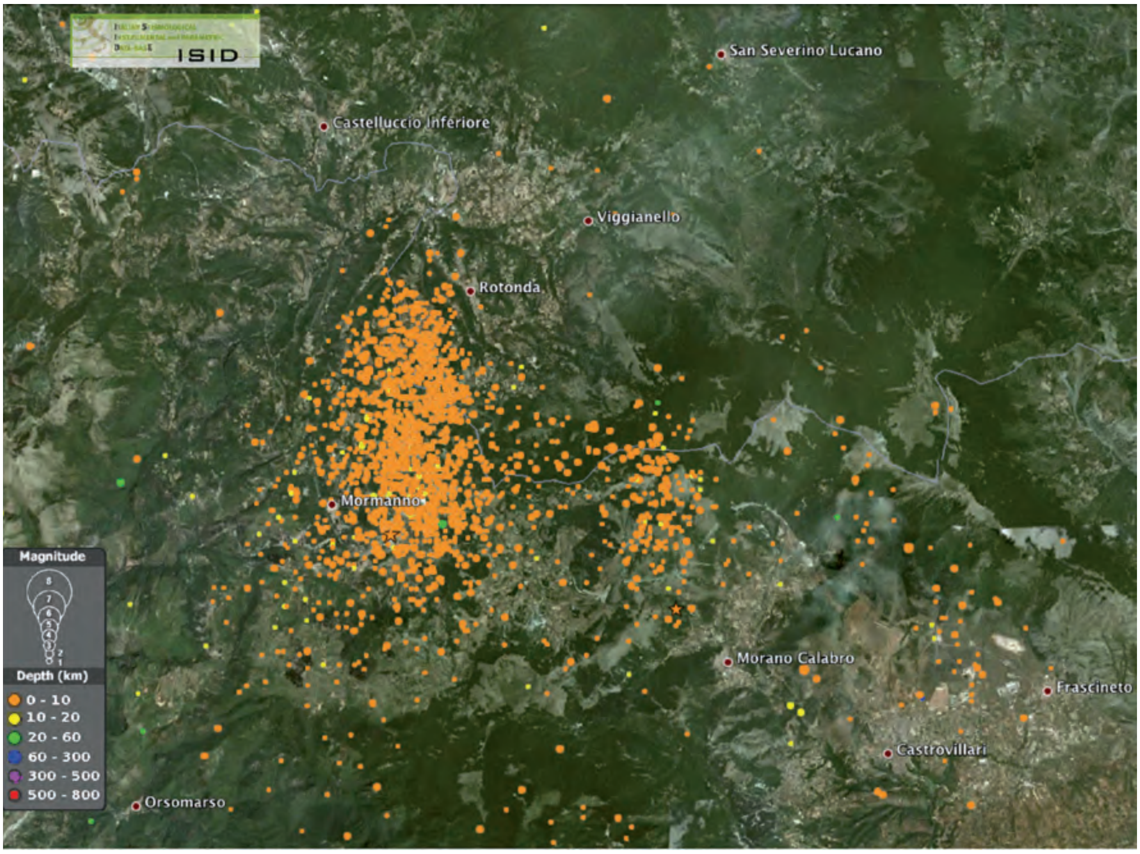


Fig. 7 - The ongoing Pollino seismic swarm: epicentres located by INGV (http://iside.rm.ingv.it).

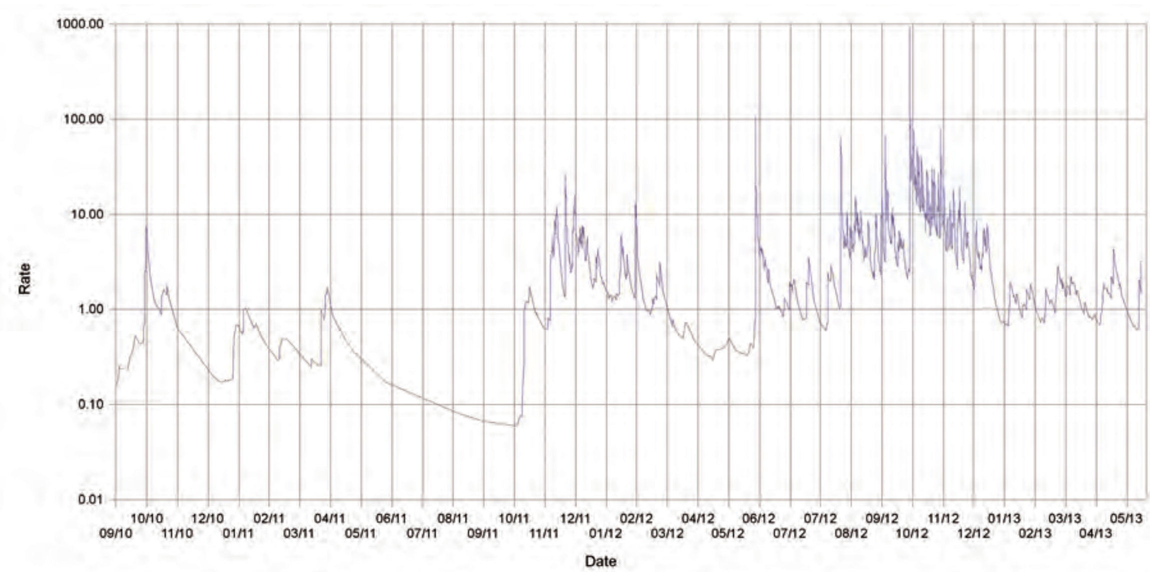


Fig. 8 - Rate of activity expressed as the number of events with $M_L > 1.5$ occurring in 24 hours.

Following this emergency management philosophy, during the more intense phase of the seismic swarm the DPC and the Civil Protection Office of the Basilicata region decided to jointly carry out some preparedness activities aimed at verifying and enhancing emergency management capacity. All activities have been carried out through a continuous and fruitful collaboration among the main stakeholders involved (scientific community, local and national governmental agencies, civil protection volunteers, citizens, etc.). Within these activities the cooperation with local institutions has been pursued in order to verify the local emergency plans and, where needed, provide suggestions to adequately update and/or upgrade them. Besides, aimed at contributing to the built-up of the culture of prevention, an outstanding work specifically devoted to appropriately communicate seismic risk mitigation concepts to citizens, volunteers, students, technicians and policy makers has been made.

4.1. Cooperation with local institutions

The co-operation between scientific community and local institutions is crucial in the effort of better facing emergency situations. It has been mainly devoted to provide assistance and information to local offices of civil protection and authorities (e.g., mayors, which are civil protection authorities in their municipality according to Italian laws). Specifically, a review of the local plans of emergency, where available, has been performed using purposely set-up forms. Content and provisions of the emergency plans have been verified and, when needed, suggestions for updating or upgrading them have been given. The main activities carried out for the examination of emergency plans were as follows:

1. check of availability and usability of the areas for post-earthquake emergency needs;
2. suggestions to update/upgrade the emergency plan contents;
3. divulgation of the emergency plan contents (also through civil protection exercises);
4. inspection of buildings deemed the most important for either the consequences of their possible collapse or emergency management needs.

Table 2 reports the main results of some activities carried out, pointing out the comparison between the state of the emergency plans at the start of the preparedness activities and at the moment of last check (December 2012). Data on 11 out of 15 villages in the Pollino area, that is those more affected by the seismic swarm, is reported in Table 2. This data emphasizes that a great deal of work is still required on local emergency plans. However, the comparison shows that, as a result of the preparedness activities and thanks to the co-operation between local institutions, 3 villages provided themselves with an accurate plan of emergency, with respect to no village at the end of 2011. Also the number of people involved in divulgation programs of the emergency plans' content and in civil protection exercises is increased from about 6,000 to 10,000 and is currently increasing.

With regard to point 4, some visual inspections have been performed on the buildings whose seismic resistance is of importance in view of the consequences associated with their collapse (e.g., schools) or whose integrity during earthquakes is of vital importance for civil protection (e.g., hospitals). Inspections have been performed by expert technicians using the post-earthquake damage and safety assessment inspection form [AeDES form: Baggio *et al.* (2007)] released by the DPC after the 1997 Umbria - Marche and the 2002 Molise earthquakes. The form collects data on the damage sustained, geometrical and qualitative characteristics (including height, plan and elevation configurations, age, type of vertical and horizontal structures, type

Table 2 - Results of the examination activities on the emergency plans of 11 villages in the Pollino area (Castelluccio I., Castelluccio S., Castelsaraceno, Lagonegro, Lauria, Maratea, Nemoli, Rivello, Rotonda, Trecchina, Viggianello).

	Start of Activities (Sept. 2011)		Last Check (Dec. 2012)	
	Number	Population	Number	Population
Villages with accurate plan	0	0	3	12005
Villages without accurate plan (to be upgraded)	5	16430	5	12715
Villages without accurate plan (to be updated)	4	23050	2	16255
Villages without plan	2	3014	1	1520
Availability of the emergency plans in electronic format	0 / 11	0 / 42495	1 /11	2175 / 42495
Divulgation of the emergency plans and people exercises	1 / 11	5800 / 42495	2 / 11	9385 / 42495

of foundation and roof) and whether the building had been retrofitted. Past earthquakes in Italy, e.g., Molise 2002 (Augenti *et al*., 2004) and L'Aquila 2009 (Price *et al*., 2012), showed the grievous consequences caused by the collapse or loss of usability of important public buildings, frequently designed without seismic criteria. Among others, particularly remarkable it has been the inspection of the building to be used as Mixed Operative Centre (COM) for the Pollino area. In fact, COM buildings are places identified in "peace-time" where the civil protection activities involving a group of neighbouring municipalities are organized in the post-event emergency phase. The visual inspection gave positive results confirming the capacity of adequately hosting the specific as well as crucial functions required to a COM building.

Finally, with respect to the availability and usability of the areas for post-earthquake emergency needs (i.e., shelter areas), the critical issues related to the identification of the area where the rescuers should be hosted have not yet been fully resolved.

4.2. Training and communication activities

A strong collaboration between DPC, INGV and ReLUIS has been established in order to transfer information to civil protection volunteers, local technicians, administrators and common people, with the main objectives of: i) enhancing the self-protection capability ("what to do" in case of an earthquake), and ii) decreasing the understandable state of worry. Specific training and communication activities mainly addressed to population, volunteers and schoolchildren have been carried out (Fig. 9).

These activities have been partially derived from two national prominent initiatives for seismic risk reduction, that are:

- the national campaign *"Terremoto, Io non rischio - Earthquake, I do not risk"* (TINR, www.iononrischio.it) promoted by DPC and National Association for Public Assistance (ANPAS, www.anpas.it), in collaboration with INGV and ReLUIS;
- the *EDURISK project*, an educational joint venture of INGV and National Institute of Oceanography and Experimental Geophysics (OGS, www.ogs.trieste.it), funded by DPC.

The two initiatives were purposely designed bearing in mind different targets. In fact, as recognized in the literature (e.g., Alesch *et al*., 2007), risk communication messages have to be

Fig. 9 - Training and communication activities of civil protection volunteers (a), students (b) and population (c).

adapted to the individuals who is specifically addressed. The first campaign (TINR) is devoted to the general public mainly by means of one-by-one information exchange, while EDURISK is specifically thought for schoolchildren.

TINR campaign aims at promoting the culture of prevention, starting from the training of civil protection volunteers to make them better aware and specialized, so that they can effectively and continuously encourage common people in acquiring a more active role in seismic risk mitigation. The rationale behind the campaign is that preventing and reducing earthquake consequences must be considered everyone's interest and task. Learning how, through an effective diffusion of information on seismic risk, fosters collective and individual responsibility and need of contributing: prevention is a right but also a duty.

The first edition of TINR campaign was held on October 22 and 23, 2011 in the squares of 9 Italian towns located in high seismicity zone. ANPAS civil protection volunteers were the main actors of the initiative. A selected group of volunteers was firstly trained by experts from DPC, ANPAS, INGV and ReLUIS on basic concepts concerning hazard, vulnerability, seismic risk and communication procedures. Then, in turn, they trained other volunteers widening the number of actors to be committed in the process of knowledge diffusion to the population. During the 2011 campaign 120 volunteers distributed information, illustrative material and provided answers to the citizens' questions on possible individual actions to carry out in order to mitigate seismic risk.

As a consequence of the positive feedback and results of the 2011 campaign, a second edition was planned and has been held on October 13 and 14, 2012 extended to 100 towns throughout the country. Also in the second edition of TINR campaign, the main actors were volunteers, in this case over 1,500 trained volunteers from 12 different national associations working on civil protection.

As for the training of volunteers, in a first phase more than 300 volunteers were trained by experts from DPC, INGV, ReLUIS and ANPAS, among which some of the authors of the present paper. Later, these volunteers trained additional 1,200 volunteers, all committed in the process of knowledge diffusion under the supervision of a selected group of "senior" volunteers, that is those ones trained during the 2011 edition of the campaign. The training process ended on September 2012 when several refresh meetings with all volunteers were held to verify that the training path had been effectively followed. Main arguments of the training program have been: historical seismicity and its memory, seismic hazard, vulnerability of the building stock and, finally, role of institutions, volunteers and common people in the mitigation of seismic risk.

Two of the 100 locations involved in the 2012 campaign are in the area affected by the Pollino seismic swarm, that is the villages of Lagonegro and Rotonda. In particular, Rotonda is the village of the Basilicata region nearer to the epicentral area of the seismic swarm. With the support of trained volunteers, the population of Rotonda has been, and currently is, continuously informed about behaviour and countermeasures to be taken before, during and after an earthquake.

Another national project, EDURISK, has been adapted to the local situation particularly in order to bring the culture of seismic risk prevention in the schools. The project focuses on the development of educational tools and activities centred on earthquakes and their mitigation, to be used in courses and campaigns for seismic risk reduction mainly addressed to students of age 4 - 18, and on their hand-on experimentation in targeted areas. For almost six years from its inception, the EDURISK staff was mostly concerned with "laboratory work": educational tools for the schools (from nursery to secondary) were planned, developed and tested within the frame of a large-scale educational campaigns, involving about 3,500 teachers and more than 50,000 students from hundreds of Italian schools. Their response to the EDURISK input found expression in a wide range of works, activities, studies, artefacts and so on, now available via the Internet (www.edurisk.it).

In April 2009, the EDURISK project was put to the test of a strong earthquake (M_w 6.3 L'Aquila earthquake). On the spot, the EDURISK staff had to devise completely new ways to carry out its work in the field, in circumstances no less demanding and infinitely more difficult than the friendly scholastic environment they had previously worked with. Completely new and original educational activities had to be devised to meet the psychological needs and answer the numberless questions of the population of the Abruzzo region. In this circumstance, as well as during the Emilia sequence in May 2012, the EDURISK project has achieved mainly public information activities and psycho-social support, through the use of educational tools developed in previous years.

Similarly, during the Pollino sequence, the staff EDURISK offered to teachers and students of Rotonda (Fig. 9) the opportunity to share and discuss their experience, using a wealth of informative materials and seismological, pedagogical and psychological skills.

For both projects, it would be interesting to evaluate the effects due to the adopted risk communication strategy, as already done in other works (e.g., Blanchard-Boehm, 1998). In order to achieve this goal, surveys on the people's awareness both before and after the risk communication campaigns are planned. Currently, data about the "before condition" was not acquired since the activities have been carried out during the emergency phase. Therefore, a systematic and quantitative measure of the results is not practicable except through the analysis of the social and territorial response to the M_L = 5.0 earthquake occurred on October 26, 2012, as discussed in the following section.

5. The M_L 5.0 earthquake of October 26, 2012: an unwanted test

Nowadays, the peak of the seismic swarm was reached with a magnitude M_L 5.0 (M_w 5.2) earthquake, which hit the Pollino area at 01.05 (local time) on October 26, 2012, followed by over 100 aftershocks which kept residents spooked between the regions of Basilicata and Calabria. An 84-year-old man died from a heart attack at Scalea, rather far away the epicentre, but otherwise no injuries were reported. Thousands of people temporarily abandoned their homes in the aftermath of the earthquake. A hospital had to be evacuated in the town of Mormanno (Calabria region), close to the epicentre, where also some damage to buildings including the local cathedral was observed. A rest home in the nearby village of Laino Borgo (Calabria region) was also evacuated. Most of schools in the affected area told pupils to stay at home.

The seismic event was recorded by the stations of the Italian National Accelerometric Network (RAN) and by some temporary stations (TS) located within the epicentral area. The closest RAN station was Mormanno (MRM) about 2 km far from the $M_L = 5.0$ shock epicentre. The MRM station, located on rock soil classified as type A ground (i.e., no soil amplification effects) according to EC8 (CEN, 2004), recorded *PGA* values up to 0.18 g. The Papasidero station (TS), that is about 8 km far from the epicentre (no data on the soil type are available at present), recorded a *PGA* value of 0.23 g. The recorded *PGA* values are close to the design seismic actions provided by the Italian seismic code (NTC, 2008) to verify the Life Safety limit state, corresponding to events with return period 475 years or, equivalently, 10% probability of exceedance in 50 years. In this sense, the October 26 event can be considered a significant test for the people and buildings' response, as well to verify the system capacity as a whole.

The buildings in the villages of the Basilicata region generally experienced low damage level. In Rotonda, located at less than 10 km from the epicentre, few buildings suffered slight damage (grade 1 according to EMS98 classification), such as hair-line cracks or fall of small pieces of plaster in the walls of some masonry buildings. The highest damage was found in the locality Piano Incoronata of Rotonda municipality, where some poor quality masonry buildings (Fig. 10) suffered moderate structural damage (grade 3 according to EMS-98), then were declared unsafe after the usability survey performed by trained technicians. In the historical centre of Rotonda only the bell tower of the Church of S. Antonio was damaged and declared unsafe, thus determining two adjacent undamaged buildings were, in turn, declared unusable. Some short-term interventions have been carried out in order to secure the belfry of the church through tightening and application of strands (Fig. 11). As for RC buildings, no structural damage was generally found on the whole affected area.

The good seismic behaviour of buildings can be partially ascribed to the strengthening programs carried out after the 1980 and 1998 earthquakes. Specifically, the buildings damaged after the 1998 earthquake were repaired and upgraded against a design seismic action equal to 60% of that considered in seismic codes for either design of new buildings or full retrofitting of existing ones. It was expected that such interventions had significantly reduced the vulnerability of the involved building stock, then the good performance found in the $M_L = 5.0$ event can be considered a first partial validation of this goal. However, it has to be underlined that no or negligible damage was found also in not strengthened buildings, presumably because the most vulnerable buildings were already "selected" by the 1998 earthquake.

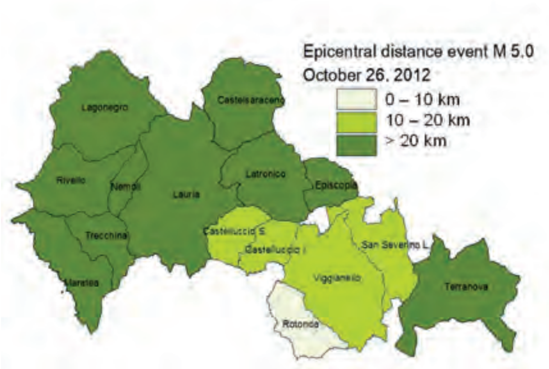
Fig. 10 - View of the most damaged building in Rotonda after the October 26, 2012 earthquake.

A macroseismic intensity survey on the villages closer to the epicentre was performed by Quick Earthquake Survey Team (QUEST) group in the period October 27 - 29 (QUEST, 2012). Its objective was to ascertain the effects produced by the event and check damage data that was reported by municipalities and local offices of Civil Protection. The preliminary results are reported in the table of Fig. 12 for the localities in Basilicata region where the higher EMS intensities were found. The maximum intensity, equal to VI EMS, was assigned to the locality Piano Incoronata.

With respect to the consequences on people, data in Table 3 shows that there were only 14 homeless on a total involved population of about 18,000 people. Out of about 530 requests of usability survey, only 30 buildings have been classified as unusable.

Slight damage was recorded also to lifelines, such us urban roads principally due to falling rocks from steep slopes, and network of utilities, namely the breakage of a small pipeline

Fig. 11 - Short-term intervention on the bell tower of the church of S. Antonio in Rotonda damaged by the M_L 5.0 October 26, 2012 earthquake.



Village	Municipality	EMS-98 Intensity
Piano Incoronata	Rotonda	VI
Rotonda	Rotonda	V-VI
Lauria	Lauria	IV-V
Maratea	Maratea	IV-V

Fig. 12 - On the left: mean distance of the villages in Basilicata region from the epicentre of the October 26, 2012 earthquake; on the right: preliminary survey of EMS-98 Intensity [adapted from QUEST (2012)].

transporting natural gas. A critical aspect in the emergency management has been the two days' disruption of the water distribution in the village of Rotonda after the springs supplying the local aqueduct were found turbid. This temporary disruption was tackled thanks to the use of emergency water tankers (Fig. 13). The population responded well and without complaint to water disruption, promptly adapting and equipping themselves for the sourcing from water tankers, although this issue was never addressed in the communication and training activities.

A good response of the population has been generally found during and after the October 26 earthquake. In fact, both during and in the immediate aftermath of the shock no panic-stricken people were observed despite of the worsening circumstance that the event happened at night (1:05 local time) and was followed by a brief power outage. Further, although practically all inhabitants of Rotonda immediately left their houses, there are no news of overreactions or especially bad behaviour. After the event, most of people returned to their houses following the suggestions that had been previously provided during the communication activities. "*The system generally worked well*" stated the Italian Emergency Preparedness head Franco Gabrielli at the end of the meeting with local institutions and Emergency Preparedness offices carried out in the morning of October 26. On the other hand, some citizens of Rotonda, interviewed by journalists just some days before the October 26 event, declared "… *we are exhausted by this endless sequence, but we are ready, too; Emergency Preparedness explained us what we can do before, during and after possible seismic events ...; I personally carried out some simple even though*

Table 3 - Usability inspection results in the most affected Basilicata villages and number of assisted people (data updated at November 5, 2012).

Village	N. of Usability Inspections	N. of Unusable Buildings	N. of Involved People	N. of Assisted People
Rotonda	379	25	39	14
Viggianello	65	3	10	0
Castelluccio I.	51	1	6	0
Castelluccio S.	26	0	0	0
TOTAL	521	29	55	14

Fig. 13 - Water supplying from emergency tankers in the urban centre of Rotonda.

important countermeasures in my house, such as fastening tall furniture to solid walls, removing heavy and fragile objects from the upper part of furniture, etc.".

We are confident that the positive people response derives, at least partially, from the preparedness and communication activities extensively carried out during the seismic swarm. As a result, this can be considered an encouraging experience in view of enhancing social capacity against seismic risk.

6. Final remarks

The experience of the Pollino seismic swarm confirms that risk communication and awareness are crucial in building social capacity to effectively cope with natural hazards.

An effective form of communication to enhance the social capacity of a community is an initiative that involves the local civil protection volunteers who well know both the area under consideration and the needs of fellow citizens. From this point of view, the approach proposed with the dissemination campaign "Terremoto, Io non rischio - Earthquake I do not risk (TINR)" appears appropriate. Although it might be unexpected, experience shows that the adult population can be the most vulnerable social group in terms of psycho-social attitudes. In fact, children and young people have more frequent opportunities of facing the problem of seismic risk, e.g., trough emergency exercises, and generally are endowed with greater psychological resources than adults to adapt and cope with emergencies. It seems therefore useful that the initiatives of risk education specifically devoted to schools, such as the EDURISK project, involve also students' families. Besides, in a local community, the understanding of an emergency situation can be improved and the adaptive capacities further developed through the discovery of cultural, religious and material traces of past earthquakes. To this purpose, attention to the historical and cultural dimension of risk has been developed both in the TINR campaign and in the EDURISK educational activities.

The main lessons learned from the activities performed during the Pollino seismic swarm are as follows:

- it is possible to take advantage of the increased awareness and risk perception to push more people toward short and long term risk mitigation actions;

- Emergency Preparedness volunteers can be a very effective mean to reach a large amount of population, provided that volunteers are carefully trained;
- the expectations about earthquake prediction raised from media without any scientific support proved to be the most difficult to be tackled: to overcome this bias, risk education in "peace time" is absolutely essential.

The behaviour of the local authorities before and during the seismic swarm was rather satisfying but uneven. In some cases the attention devoted to the problem followed the ebb and flow pattern of the seismic sequence, with peaks of attention following the peaks of seismicity.

The strengthening interventions executed on the building stock after the 1980 and 1998 earthquakes proved to work well, with slight damage after the strongest event (M_L= 5.0), i.e., an intensity that in some past events caused serious problems to the fragile building heritage of Italy.

Further, an encouraging experience in view of building and enhancing social capacity against seismic risk has been the positive response from common people shown during the October 26, 2012 event. Although data about the "before condition" was not available, it is deemed that the preparedness and communication activities carried out during the seismic swarm played an important role to achieve this goal.

Currently the seismic sequence, and thus the activities herein described, is still ongoing. Therefore, analysis and discussion of pros and cons of the actions taken are still ongoing, especially in order to quantify the increase of people resilience (know-how, perception, awareness, etc.).

Acknowledgements. This study has been partly supported by 2010 - 2013 DPC-ReLUIS project in the frame of Line 3.2. The authors are grateful to all Civil Protection volunteers, local administrators, technicians and citizens involved in the preparedness and assistance activities for their suggestions and, above all, for their practical example.

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Corresponding author: Angelo Masi
Scuola di Ingegneria, Università della Basilicata
Viale dell'Ateneo Lucano 10, Potenza, Italy
Phone: +39 0971 205061, fax: +39 0971 22115, e-mail:angelo.masi@unibas.it