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A catalogue of non-tectonic earthquakes in central-eastern Italy

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ABSTRACT

Quarry explosions and other non-tectonic signals can contaminate seismic catalogues, especially in areas where dense seismic networks allow to detect even low energy events. This paper presents the algorithm adopted for the discrimination of non-tectonic earthquakes in central-eastern Italy, an area with a high rate of events of this kind (4500 were recorded in the 1996-2012 period). Starting from an empirical classification based on the analysis of areas in which the ratio between daytime and nighttime events is strongly anomalous, a waveform similarity approach allows to simplify the procedure of detection making the final classification more robust. The resulting catalogue of non-tectonic earthquakes (quarry blasts and other anomalous signals) is a useful tool for anyone wanting to carry out a careful analysis of the tectonic seismicity of central-eastern Italy.

1. Introduction

It is well known that seismic networks allow to record signals generated not only by natural earthquakes, but also by artificial sources. Quarry blasts are the most common type of phenomenon routinely recorded. As quarry blasts usually are low energy events, obviously it is more frequent to record them in areas where the detection threshold of a seismic network is lower. The inclusion of these events in earthquake catalogues can contaminate our view of the true natural process under investigation, in term of both space and time distribution.

The identification of quarry blasts, and of artificial-source earthquakes in general, is not always straightforward; waveforms generated by artificial sources are usually characterized by a large amount of heterogeneity [Fäh and Koch 2002], so that a single criterion, linked e.g. to the S/P amplitude ratio or to the spectral characteristics of waveforms is not always sufficient for a safe classification. For example Allmann et al. [2008] found that quarry blasts in southern California exhibit anomalously high spectral fall-off rates compared to earthquakes of the same estimated moment magnitude, but this discriminant is not able to completely separate the two populations of events.

Only in particular cases, the joint use of feature extraction from spectral characteristics [Del Pezzo et al. 2003] or from both spectral and waveform features [Scarpetta et al. 2005] introduced in neural networks proved able to discriminate between natural and artificial seismicity. A similar approach, based on spectral and amplitude parameters introduced in artificial neural nets, had been already used by Musil and Plesinger [1996] in order to discriminate between microearthquakes and quarry blasts in west Bohemia. More recently, Lyubushin et al. [2013], working on a rather limited data set from the region of Aswan Dam in Egypt, were able to discriminate earthquakes and explosions using a multi-fractal spectral analysis.

In the routine analysis of the seismicity recorded in central-eastern Italy by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) team, and formerly by the Osservatorio Geofisico Sperimentale di Macerata (OGSM) team, a purely empirical approach has been traditionally adopted. After having recognized the existence of distinct quarry areas in the monitored region, and analyzed the most significant waveform characteristics of the relevant signals [Parolai et al. 2002], a preliminary event classification was introduced in the procedure of data picking, locating and archiving.

In this work, starting from this classification we construct a fully-checked catalogue of non-tectonic source events for the studied area. The catalogue includes not only quarry blasts, but also other events whose waveforms suggest a non-tectonic source; these data can be used as a reference for the extraction of catalogues of natural seismicity. In our opinion, this represents a more efficient alternative with respect to the sometimes adopted criterion of eliminating all daytime events in the areas recognized as prone to artificial-source events [Wiemer and Baer 2000], that in this case could lead to the suppression of a significant amount of natural seismicity, and to the lack of recognition of different non-tectonic source events, not characterized by a strict occurrence in the daytime hours.

2. The available data

This work is based on the routine analysis of local seismicity performed by the staff of the Rete Sismica Marchigiana (Marchesan Seismic Network; RSM). This network was managed by the OGSM up to 2002, when the Marche Region administration took direct control of earthquake monitoring on a regional scale, starting at the same time a close cooperation with INGV that led to a progressive integration of the regional seismic network within the national network, completed in 2009.

During the 1996-2012 period studied in this paper, the network was in an almost continuous state of evolution that transformed the merely local 16-stations network, mostly recording in dial-up mode of the early years [Parolai et al. 2001] into the integrated 96-stations RESIICO (central-eastern Italy integrated seismic network) with continuous data transmission and recording [Monachesi and Cattaneo 2010, D'Alema et al. 2011, Monachesi et al. 2013]. Hand in hand with the expansion and optimisation of the network, its detection capability did also increase with time. Figure 1 shows the geometry of the network at the end of the analysed period, together with the geographic distribution of the areas characterized by non-tectonic events (to be discussed later on).

In the 1996-2012 period, the routine analysis of the seismicity allowed to locate 68208 events (Figure 2). An analysis of the seismicity of the area is beyond the purposes of this work (see De Luca et al. [2009] and Carannante et al. [2013] for examples of how sub-sets of these data have been used); here we can just note that seismicity is quite diffuse in the whole area, with a higher concentration of epicentres along the Apenninic chain but with a significant number also in the surrounding areas, and particularly at the Adriatic border of the chain. The distribution of depths is uneven: very shallow earthquakes are prevalent in the western side of the area (inner Umbria) and along the Umbria–Marche Apennines, while deeper events occur in the outer Marche foothills.

In case of natural earthquakes, we would expect that their distribution during the hours of the day

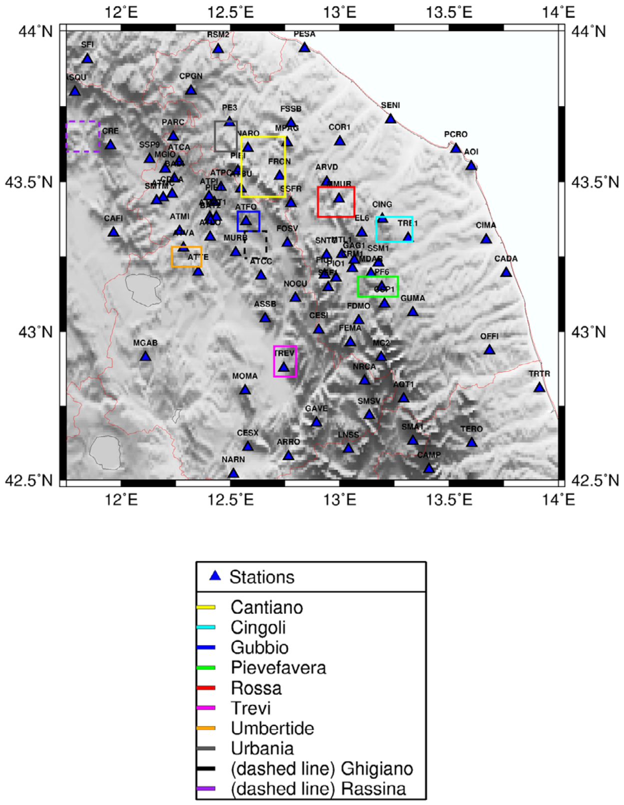

Figure 1. Map of the stations used in this paper, and of the recognized source areas of non-tectonic events. Solid lines: quarry areas. Dashed lines: other non-tectonic sources.

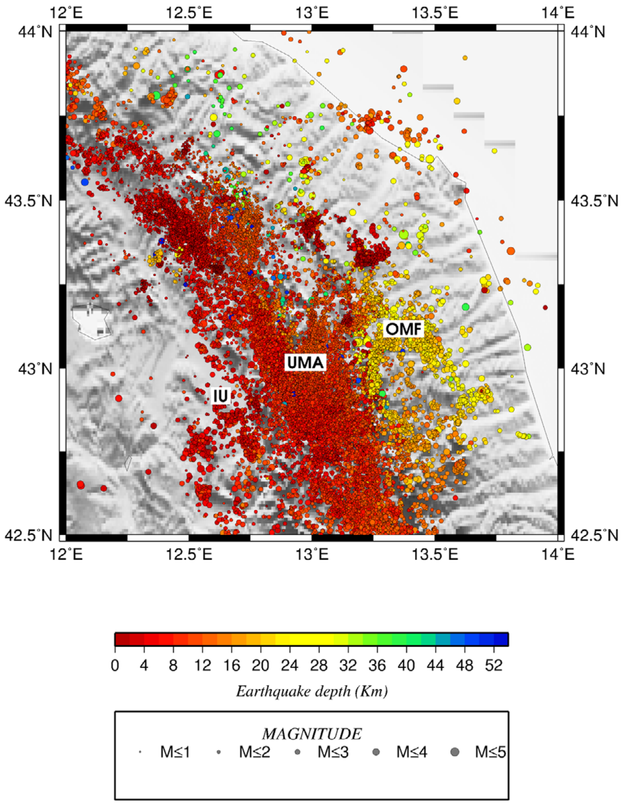

Figure 2. Seismicity recorded in the period 1996-2012. Size of the symbols is proportional to magnitude, color is a function of focal depth. IU = inner Umbria; UMA = Umbria–Marche Apennines; OMF = outer Marche foothills.

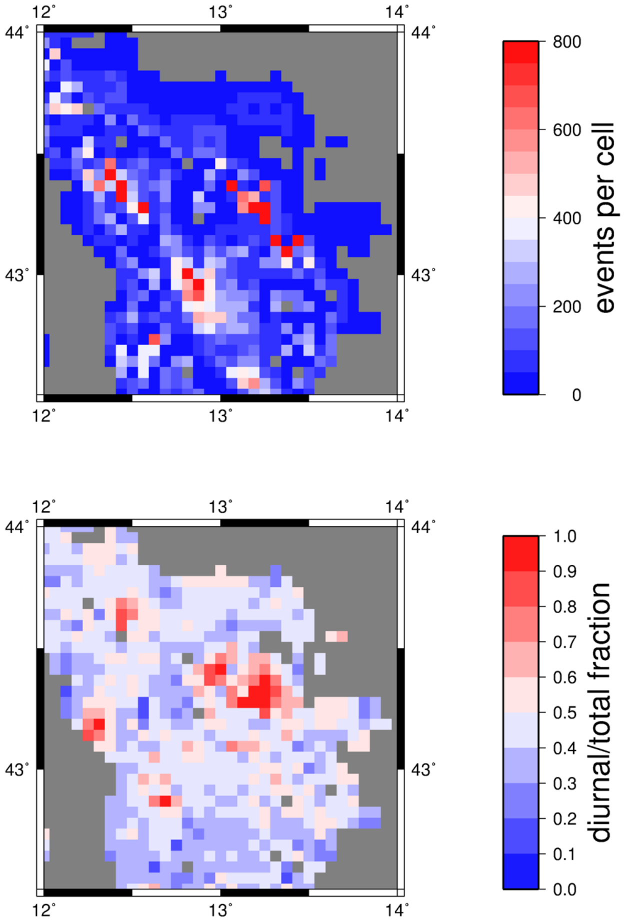

Figure 3. Day/night distribution of events. Top panel: number of events for each cell. Bottom panel: ratio of daytime to total events for each 5 km square cell. Dark blue and dark red colors depict the most anomalous areas.

should be at random, so that we should count the same number of events, as a mean term, during the day and during the night. Indeed, taking as daytime hours those between 5:00 UTC and 17:00 UTC (i.e. between 6:00 and 18:00 local time), we may count for the whole area 31,342 events during the day and 36,866 during the night, i.e. about 45% and 55%, respectively. A small prevalence of nighttime events can be easily explained with the average lower ambient noise, which influences the detection threshold of the seismic network [Marzorati and Bindi 2006].

However, if we restrict the analysis to singular cells, the result is rather different (Figure 3). The area has been divided in cells 5 km wide, and events falling within each cell are counted, divided in daytime and nighttime ones. If the total count does not reach a significant threshold for statistics (we chose the value of 20 hits), the events falling in the 8 surrounding cells are summed up. For the sake of comparison, the total hit count for each cell is reported in the top panel of Figure 3.

It is quite evident that, while in most areas values close to the mean value of 0.45 are obtained, some particular areas show anomalous values, mainly on the positive side. These positive anomalies (indicating a much larger number of events during the day than during the night) cannot be justified by statistical fluctuations, as they are often referred to areas with a high hit count. The more plausible justification is that at least part of this seismicity is related to quarry blasts.

It is well known that quarry explosions are generally performed during the daytime hours [Rydylek and Sacks 1989, 1992, Wiemer and Baer 2000].

If we extract the events located in the most anomalous area (between 43.2N and 43.5N, and between 12.8E and 13.3E), and we plot the histogram of their distribution in the different hours (Figure 4), we can notice a bimodal plot, with a strong concentration around 10-11 UTC and 16-17 UTC. These hours are linked to the midday break and to the end of the working day, and thus they represent the preferred choice for blasting time in most quarries. However, on the same plot, we can notice a rather significant number of events also in the night hours; these events are randomly distributed in time (mean term of about 100 events/hour, in the whole period) and can be easily classified as natural seismicity. In such cases, the acceptance of the method proposed by Wiemer and Baer [2000], based to the removing of all the daily events of the area, would lead to the removal of a significant amount of natural seismicity.

The existence of quarry blasts in this area is already known: Parolai et al. [2002] were able to characterize some of their sources in term of sonogram characteristics, while Mele et al. [2010], analyzing the Italian Seismic Bulletin of 2008, recognized several quarry blast areas in Italy, two of which are included in the area considered in this work.

Acting on this knowledge, the operators of the RSM network introduced in the routine processing of

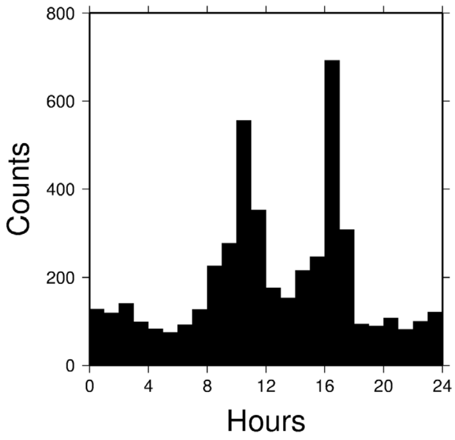

Figure 4. Histogram of the hourly distribution (UTC time = local time – 1) of the seismicity extracted from the most anomalous red areas in Figure 3. It is evident the strong concentration around two peaks, but also the existence of a significant seismicity during the night.

the local seismicity an event classification that allowed defining a located earthquake as "sure quarry blast" or as "probable quarry blast".

In some cases, the waveforms recorded from a quarry blast are quite easily recognizable: Figure 5a displays a typical example, related to a quarry blast in the "Gubbio" area. Waveforms are characterized by a clear P arrival, the lack of a clear S arrival and a later low frequency, high amplitude wave train that can be easily classified as "ground roll". In a few cases, stations close to the epicenter show also a high frequency and strongly delayed signal, that can be interpreted as the sound propagation of the shot (see Figure 5b for an example recorded close to the "Rossa" quarry area). In other cases, the classification is not so easy: Figure 5c shows a typical recording of a quarry blast in the "Cingoli" area. In this case the S waves are quite clearly recognizable and there is no evidence of energetic surface wave propagation. The main difference with respect to the recording of a local earthquake in the same area is linked to a more monochromatic character of the waveforms, in particular for the closest stations. More in detail, the spectrum of these events is characterized by a steeper fall-off at high frequency with respect to tectonic events, as observed also by Allmann et al. [2008], joined with higher amplitudes (a sort of resonance) in the frequency band 2-8 Hz. These waveform characteristics, and the compatibility of a superficial hypocenter with the recorded arrival times, drive the above described event classification.

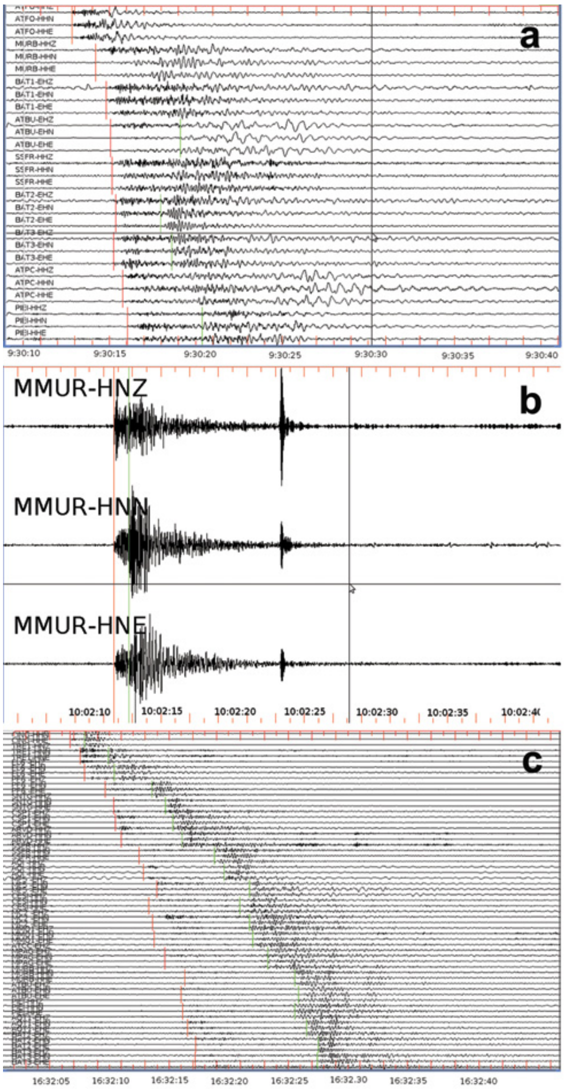

Figure 5. (a) Recordings for a quarry blast in the "Gubbio" area. Note the lack of a clear S onset, and the low-frequency signal in the coda ("ground roll"). (b) Quarry blast in the "Rossa" area recorded at the closest station MMUR (about 5 km). Note the high frequency signal about 12 s after the P wave, related to the sound propagation. (c) Recordings for a quarry blast in the "Cingoli" area. In this case identification is less straightforward.

In this work, we reanalyze the complete data set in order to verify the reliability of this classification. This analysis leads to the construction of a catalogue of quarry blasts and other probable artificial-source events for the whole analyzed period.

3. Data analysis

A more careful analysis of the maps of the ratio between daytime and nighttime events, integrated with previous studies (in particular Parolai et al. [2002]) and field surveys, led to the definition of 8 quarry areas (the same already displayed in Figure 1). In general, it is impossible to refer to a singular quarry: the extraction activity evolved in time, with the opening (and closing) of several quarries. In addition, we recognized another two anomalous areas, characterized by an opposite anomaly (a large majority of events during the night). We will discuss these latter cases in a later paragraph.

Each area was defined in term of its geographical coordinates, taking into account also the possible location error, at least for the majority of the events, and the whole catalogue was searched for events falling within one of the areas thus defined. It is quite evident (Figure 1) that in some cases the size of the area is larger by far than the actual quarry area, because we can expect also large location errors, due to the sparse geometry of the network in the first period of activity. This is the case of areas that had been active in the first period of analysis: a typical example is the "Cantiano" area. On the contrary, areas in which the network growth was very fast, such as the westernmost part, linked to the installation of the TABOO: Alto Tiberina Near Fault Observatory [Chiaraluce et al. 2014], the first event detections were already linked with good quality locations, which allowed for a smaller size of the area: typical examples are the "Gubbio" and "Umbertide" areas. In other cases, such as "Cingoli" and

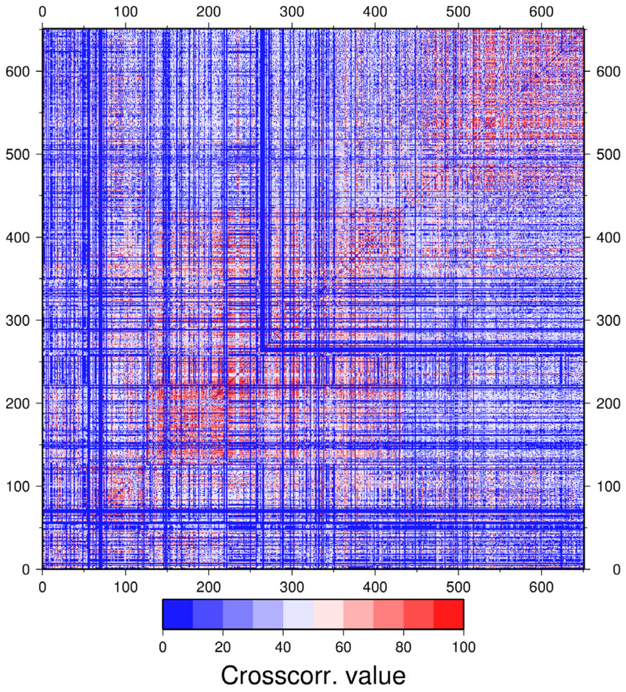

Figure 6. Cross-correlation matrix for the 651 events classified as quarry blasts in the Cingoli area in the period August 2009 - December 2012. Red colors represent high similarity. Different families are recognizable, confirming the evolution in time of the quarry activity.

"Rossa", the extension of the quarry area (several kilometers) has a larger effect on the selection of the geographical limits.

A preliminary catalogue of potential quarry blasts was thus obtained. All the events included in this catalogue that were already classified as "sure quarry blasts" have been directly included in a second-level catalogue. In any case, a waveform similarity check was performed within the preliminary catalogue: for each area, the cross-correlation between the waveforms recorded at the different stations for pairs of events was computed, with special reference to the average value of the 3 stations presenting the highest peak correlation value. The cross-correlations are normalized to the auto-correlation of each signal and measured in percentage, so that identical signals will furnish a value of 100. An example of the matrix of values obtained for a particular quarry area (the "Cingoli area") is presented in Figure 6, for a time-limited subset (August 2009 - December 2012). It is evident that most events show high correlation values with other events in the same sub-set of data; moreover, a few different "families" of events are recognizable: this is linked to the evolution of the mining activity in time, and to the existence of several quarries in the same area.

All events presenting high correlation values (above 70) with at least another event included in the second-level catalogue were included in the final catalogue.

It is worth noting that in this application, for the sake of simplicity and given the large amount of available data, we preferred to use the more straightforward (and fast) procedure of direct cross-correlation of the waveforms, band-pass filtered between 2 and 15 Hz, with respect to the more complex procedure of cross-correlating the relevant sonograms adopted by Parolai et al. [2002].

The same cross-correlation procedure was applied to the events classified as "probable quarry blast", either falling or not falling in any of the defined source area, and to the events not classified as "probable quarry blasts" but falling in these same areas. Even in this case, a high correlation value led to the introduction of the event in the final catalogue.

Finally, the events not classified as quarry blasts by the algorithm described above and falling in any of the defined areas were visually inspected in order to confirm the correctness of their exclusion from the quarry blast catalogue.

As a final result, 3258 events were classified as quarry blasts, each of them was assigned to a specific quarry area; the results are summarized in Table 1, where for each quarry area the coordinates used for the selection and the relevant number of classified events are reported.

The distribution of these events per hours of the day

Quarry area	Min.lat	Max.lat	Min.lon	Max.lon	N.ev.
Cantiano	43.450	43.650	12.550	12.750	121
Cingoli	43.300	43.383	13.167	13.333	2049
Gubbio	43.335	43.400	12.533	12.633	83
Pievefavera	43.117	43.183	13.083	13.267	253
Rossa	43.383	43.483	12.900	13.067	434
Trevi	42.850	42.950	12.700	12.800	222
Umbertide	43.217	43.283	12.233	12.367	35
Urbania	43.600	43.700	12.430	12.530	61

Table 1. Quarry areas identified in this work. Coordinates are reported in fractional degrees of latitude and longitude. Last column: number of events assigned to each area.

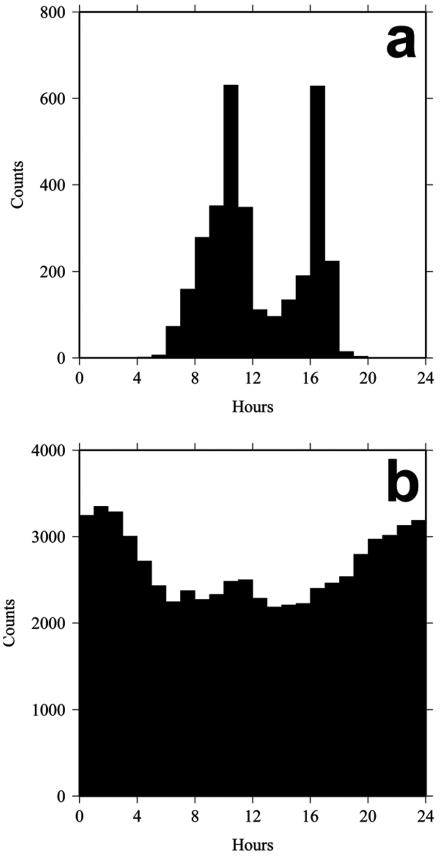

Figure 7. Histogram of the hourly distribution (UTC time = local time – 1): (a) of the seismicity classified as "quarry blasts"; (b) of the seismicity classified as "tectonic events". In (a), the trend detected in Figure 4 is confirmed, and no events outside the day hours are included. In (b), events during the night are marginally more frequent, due to the lower ambient noise and thus better network detection.

(Figure 7a) confirms what can be observed in Figure 4, and indirectly confirms the correctness of the selection; indeed all these events happened during the daytime hours, and the already observed two peaks of maximum recurrence around 10 and 16 UTC are even more evident. On the contrary, the complementary picture of the tectonic events, obtained by subtracting the quarry blasts from our catalogue (Figure 7b), shows a more regular behaviour, with a small predominance of events during the night, due to the increased network sensitivity.

4. Other non-tectonic sources

The record of peculiar events in the analyzed area is not limited to quarry blasts. As the network extended in the western sector during the last few years, some peculiar signals characterized by low frequency, nearly monochromatic waveforms and lack of evident S-wave arrivals (see Figure 8 for an example) began to be recognized by the automatic detection procedures routinely analyzing the continuous recordings. These events were classified as non-volcanic tremors by Piccinini and Saccorotti [2008] and by Saccorotti et al. [2011]; more recently Latorre et al. [2013] did propose an artificial source, based on the distribution of these events between working days and holidays, and on the similarity of the waveforms among events generated in different geological frameworks, but always in areas characterized by the presence of a particular kind of cement plant.

We will simply classify these events as being due

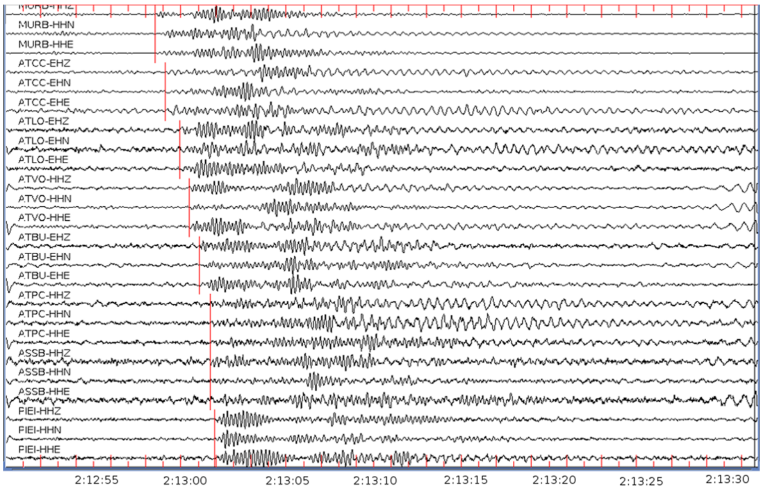

Figure 8. Example of a "low frequency" event in the Ghigiano area. The nearly monochromatic character and the lack of S waves are evident.

Source area	Min.lat	Max.lat	Min.lon	Max.lon	N.ev.
Ghigiano	43.245	43.335	12.565	12.665	1209
Rassina	43.600	43.700	12.750	12.900	28

Table 2. Source areas of other non-tectonic seismic signals identified in this work. Coordinates are reported in fractional degrees of latitude and longitude. Last column: number of events assigned to each area.

to "non-tectonic sources". In the analyzed area, two main source zones with this kind of sources can be recognized, leading to the recognition of 1237 events in total (Table 2).

For these events the distribution of the events in the daytime hours is opposite to that observed for the quarry blasts (Figure 9). The strongly prevailing number of nighttime events for the "Ghigiano" area was already recognizable in Figure 3 (bottom, the most evident dark blue spot, corresponding to a high hit count cell). This is probably due not only to the energy of the phenomenon itself, but also to our capability of detection: dealing with very low energy events, the slight increase of noise level at the recording stations in daytime makes it more difficult to detect these events. A more detailed search at the closest stations allowed recognizing the recurrence of a high number of such events also during the day hours [Latorre et al. 2013].

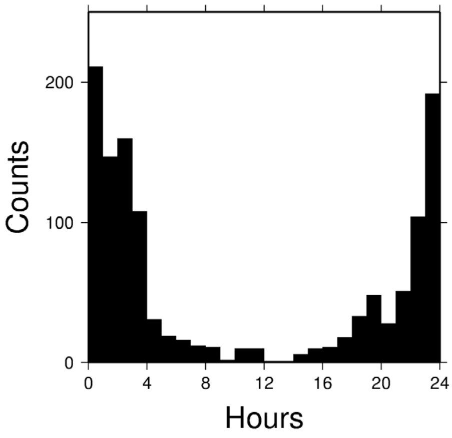

Figure 9. Histogram of the hourly distribution (UTC time = local time – 1) of the seismicity classified as "other non-tectonic sources". Events during the night hours are strongly prevailing.

5. Use of the catalogue of non-tectonic earthquakes

The catalogue of non-tectonic earthquakes that has been compiled in this way can be used for extractions: Figures 10 and 11 display maps of the tectonic and non-tectonic seismicity recorded in the whole studied period by the former RSM and present RESIICO networks. A comparison between Figure 10 and Figure 2 points out how, in particular, the exclusion of quarry blasts allows to improve the characterization of the seismicity on the Adriatic side of the Apenninic chain, mainly in term of depth distribution. Indeed, in this sector most seismicity is confined in deeper layers than in the areas along the chain or on the Thyrrhenian side

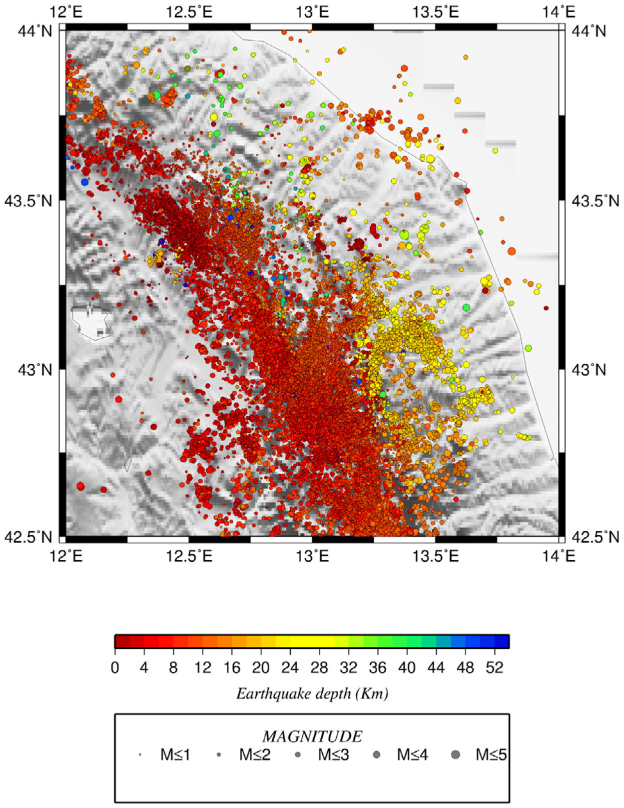

Figure 10. Seismicity for the period 1996-2012, as derived from the same catalogue of Figure 2 with the subtraction of the events classified as "non-tectonic source". Note the different mean depth distribution, in particular in the area between 43.3 and 43.5N, and between 13.0 and 13.5E.

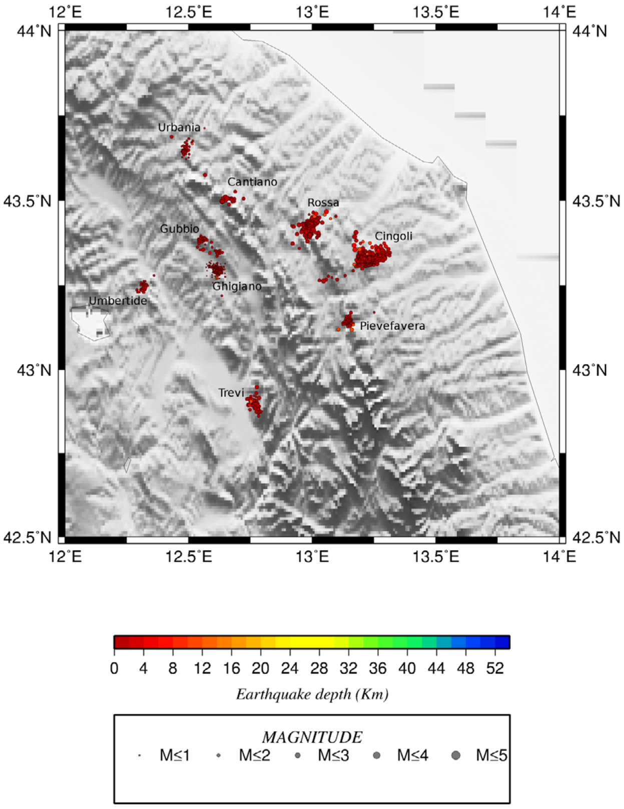

Figure 11. Map of the events classified as "non-tectonic source". Note that even some strongly mis-located events were included in the catalogue, by means of the waveform similarity.

[Carannante et al. 2013], although some spots of very shallow seismicity can be recognized. This trend was "hidden" in Figure 2 by the superposition of quarry blast hypocenters.

In Figure 11 it is worth noting how some strongly mis-located events, with epicenters far from the quarry areas, can be included in the catalogue by means of the waveform similarity approach. Indeed, when the control procedure furnishes high correlation values in the comparison between events classified as quarry blasts and an event located also far from the relevant quarry area, the event is classified as quarry blast, irrespective of the location. This is particularly useful in case of weak events recorded by few stations, characterized by unstable locations.

The selected catalogue shown in Figure 10 can be used for a comparison between daytime and total events on cells (Figure 12). A comparison between Figure 12 and Figure 3 shows that the most evident anomalies of the original catalogue have been removed by the selection procedure.

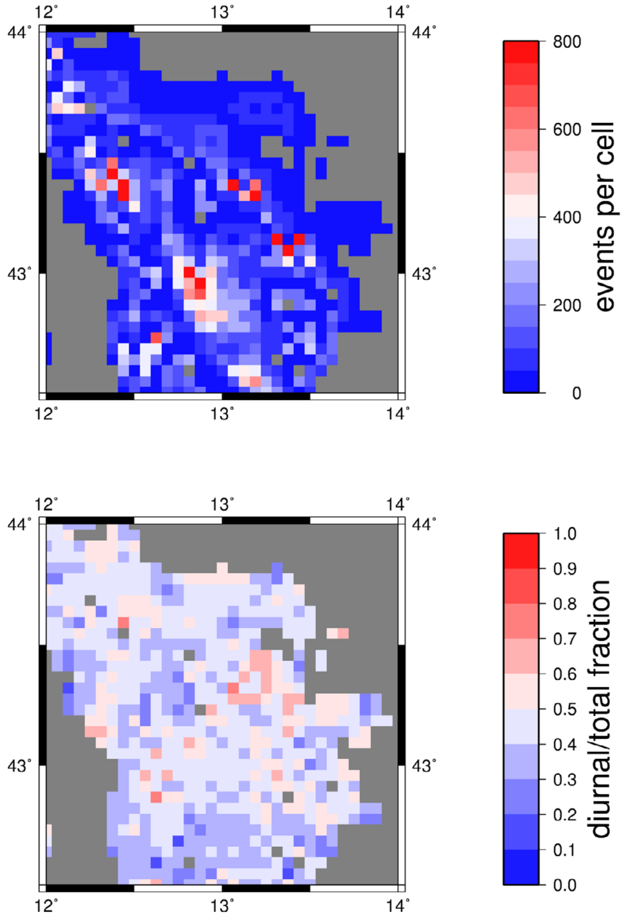

Figure 12. Day/night distribution of events in the catalogue with non-tectonic events removed. Top panel: number of events for each cell. Bottom panel: ratio of daytime to total events for each 5 km square cell. Dark blue and dark red colors depict the most anomalous areas. The residual anomalous areas are now linked to low-sampled cells.

Obviously the catalogue can be used in order to distinguish between tectonic and non-tectonic earthquakes also in data coming from other sources, simply by comparison of origin time and epicentral location. Taking as an example the Italian Seismological Instrumental and Parametric Data-base ISIDE (http://iside.rm.ingv.it), it is possible to recognize, for the period 2005/04/16 – 2012/12/31 available on-line, 1583 events that are close both in time and in position to events included in the catalogue of non-tectonic earthquakes; these events can thus be defined as non-tectonic events with a very high reliability.

Going back in time, an analysis of the CSI catalogue (Castello et al. [2006], http://csi.rm.ingv.it) for the period 1996-2002, led to the definition of 449 non-tectonic events, while an analysis on a preliminary version of the new release of CSI (CSI 2.0, Di Stefano, p.c.) for the period 2003-2007 led to the definition of 953 non-tectonic events.

The complete catalogue of non-tectonic events is presented in the electronic supplement, together with the above defined possible correlations with records of the existing catalogues. For CSI and CSI2.0, the event ID is reported, while for ISIDE, where an event ID is not present, the origin time is reported. Some examples of waveforms recorded at the RSM for non-tectonic events in the different source areas are also inserted in the electronic supplement.

Our proposal is to update this catalogue on a regular basis; the new releases will be made available on the page http://www.an.ingv.it/NTSEQS/ntseqs.html.

6. Discussions and conclusions

In this paper a catalogue of non-tectonic events for central-eastern Italy is presented. In our opinion, this catalogue is rather robust: waveforms recorded for each event were used in order to construct families of events characterized by high similarity. The attribution of each family to a particular source area (quarry or other non-tectonic source) was based on rather empirical criteria, but the final result, in term of space-time distribution of these events, in our opinion represents an *a-posteriori* confirmation of the correctness of the choice. Indeed we were able to extract, from a generic seismicity catalogue, two sub-catalogues (quarry blasts and other non-tectonic sources) characterized by a peculiar distribution of events during the day. In particular, all the events classified as quarry blasts occur during the daytime hours.

Obviously we can not assure that our non-tectonic events catalogue is complete. For the low-frequency events, a more detailed analysis [Latorre et al. 2013] led to recognize that these events are very frequent, and that our detection system just recognizes the most energetic ones. More in general, it is possible that other quarry areas, characterized by a less frequent and less energetic blasting activity, could be present in the area. At the same time, other explosions could be present in our seismicity catalogues: for example, few cases of shots related to new road openings were recognized, even if usually in these cases a more rigid use of ripple firing strongly limits the energy of the propagated waves. Nonetheless, we are quite confident that in our residual "tectonic" catalogue the incidence of non-tectonic sources should be negligible.

On the contrary, our choice of a more systematic search for quarry blasts, with respect to the easiest choice of eliminating all the day-time events in the areas prone to quarry activity, allowed us to maintain a more complete information of the tectonic seismicity in these areas. For example, in Figure 13 we analyze more in detail the area surrounding the quarry zones "Cingoli" and "Rossa". In Figure 13a the whole seismicity is reported: it is not possible to discriminate between quarry shots and some possible seismic sequences. Figure 13b reports the "tectonic source" catalogue, as in Figure 10. It is evident the existence of two clusters of shallow activity; the most evident one was very active in April 2012, with earthquakes felt in the area and reaching magnitude 3.0. Figure 13c shows the seismicity resulting in the area after subtraction of the events occurring during day hours, as suggested by Wiemer and Baer [2000]. It is evident that part of the tectonic seismicity disappears. In particular, for the above-mentioned sequence, by chance all the most energetic events (5 events above magnitude 2.5) occurred during the day. More recently, two more sequences (Cupramontana, April 2013, and Gubbio, September–December 2013) affected areas overlapping the defined quarry zones, confirming the need for a careful discrimination of events.

The removal of non-tectonic events has a direct impact on the statistical characterization of seismicity: as an example, we computed the b-value of the Gutenberg and Richter [1944] relationship, for the area described in Figure 13, by using the whole catalogue (Figure 14a), the catalogue of quarry blasts (Figure 14b) and the catalogue of tectonic events (Figure14c). The b values have been computed by using the maximum likelihood approach, as implemented in the ZMAP software package [Wiemer 2001]. It is evident that the b estimate on the whole catalogue (1.47±0.09) is quite strongly biased by the introduction of quarry blasts, that are characterized by a strongly anomalous magnitude-frequency distribution (b = 2.48±0.16), while the tectonic events catalogue shows a more usual b value (1.28±0.08).

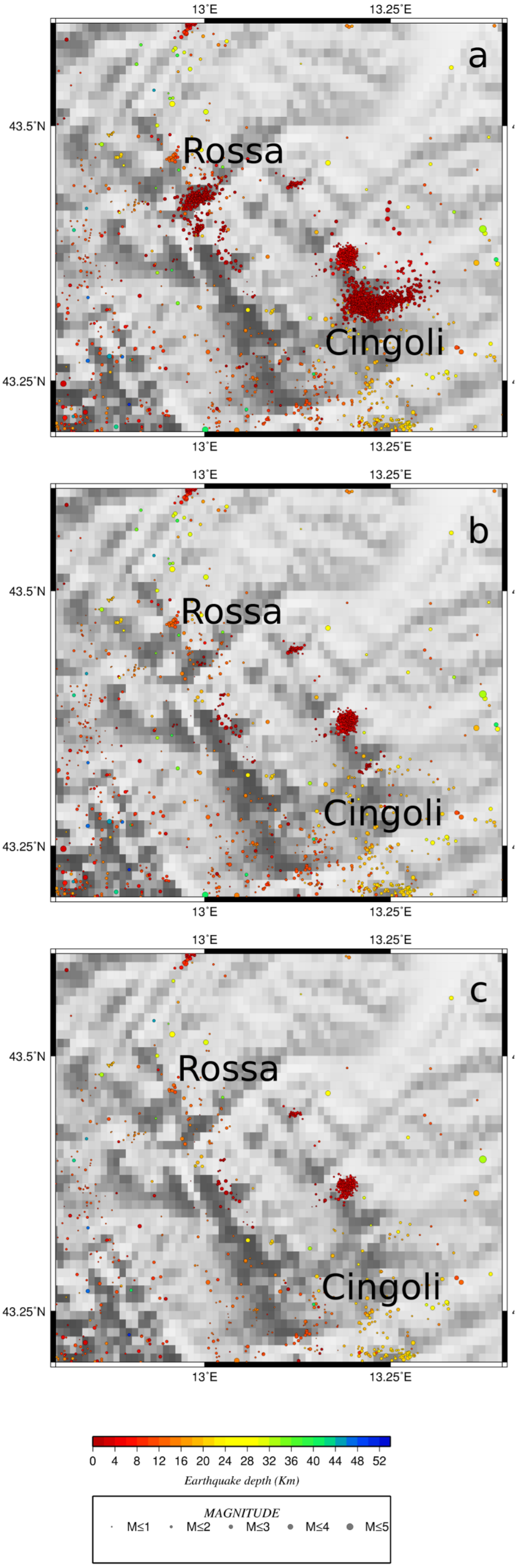

Figure 13. Zoom of seismicity in a zone comprising quarry areas "Cingoli" and "Rossa". (a) Whole catalogue (as in Figure 2). (b) "Tectonic-source" events (as in Figure 10). (c) Catalogue after eliminating day-time events.

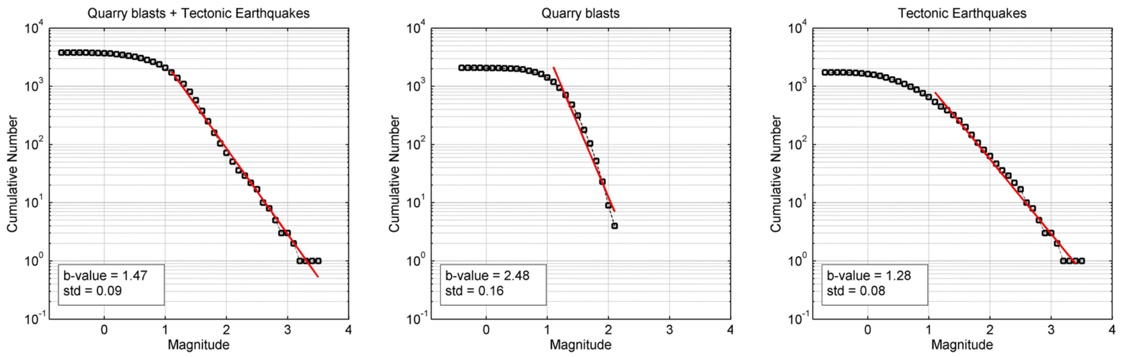

Figure 14. Cumulative number of events as a function of magnitude for the area depicted in Figure 13, and relevant b-values. (a) Whole catalogue. (b) Quarry blasts. (c) Tectonic events.

7. Data and sharing resources

1. Catalogue of non-tectonic events in central-eastern Italy, 1996-2012

Record Format:

1-12: Event ID in the RSM database
14-92: event location, hypo71 format
14-30: origin time
32-39: latitude
41-49: longitude
51-56: depth (fixed at 0., sometimes the location program overrides the setting)
60-63: local magnitude
64-66: number of phases with non-zero weight in the location
68-70: maximum azimuthal gap
71-75: distance of the 3-rd closest station
76-80: root mean square of residuals of the final location
82-85: erh, max. horizontal projection of the error ellipsoid as computed by Hypoellipse (km)
87-90: erz, max. vertical projection of the error ellipsoid as computed by Hypoellipse (km)
92: summary location quality, as assigned by Hypoellipse (A: best, D: worst)
94-102: ID of corresponding event in CSI
104-112: ID of corresponding event in CSI2.0
114-132: origin time of corresponding event in ISIDE
134-144: name of the source area.

2. Examples of non-tectonic events recorded in the different source areas. It is to be noted that the time window of the event in the "Rassina" area contains also an event of the "Ghigiano" area.

Source area	**Event ID**
Cantiano	030114151920
Cingoli	121212163050
Gubbio	121212092946
Pievefavera	120604100626
Rossa	121218145154
Trevi	121010062234
Umbertide	121009091946
Urbania	121123092010
Ghigiano	120703021234
Rassina	122629232434

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