

# Behind the Italian catalogues: overlooked but far from negligible earthquakes

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## Abstract

The Italian parametric earthquake catalogue is the result of several decades of historical seismological research, based in its turn on a centuries-long tradition of descriptive earthquake compilations. Thanks to historical seismological research undertaken since the mid-1980s, knowledge of the major historical earthquakes in Italy has hugely improved. These studies, however, focused mainly on earthquakes already recorded in Mario Baratta's extensive compilation *I terremoti d'Italia* (a summary of earlier descriptive earthquake studies, published in 1901), rather than on the identification of earthquakes still 'unknown' to the Italian seismological tradition.

As the results of a systematic perusal of 'serial' historical sources show, it is still possible to discover locally significant earthquakes (i.e. important for improving seismic history and hazard assessment of given localities or areas) that no previous studies had ever considered. Initiating new research projects specifically aimed at the identification of earthquakes unknown to the seismological tradition is therefore essential to improve hazard assessments on a subregional and local level.

Keywords: Historical seismology; Seismological tradition; Earthquake catalogues; Unknown earthquakes; Seismic Hazard

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## 1. First attempts at taking stock of Italian historical seismicity in the late 1800s

Between the years 1861 and 1871, most of the Italian peninsula was unified into a single political entity, after having been split for centuries into several regional and sub-regional states, each with its separate laws and administration. The new *Regno d'Italia* (Kingdom of Italy) had to establish a unified administrative structure and new offices for dealing with specific topics. The *Servizio meteorologico nazionale* (founded in 1879) was charged with collecting and managing meteorological and seismic data. Then, after the severe earthquake of 23 February 1887 (Liguria, NW Italy), the *Consiglio Direttivo di Meteorologia e Geodinamica* was instituted and provided with a *Ufficio centrale di Meteorologia e Geodinamica* (henceforth UCMG), located in Rome and charged, through its *Servizio Geodinamico* branch, with the task of collecting information on the effects of earthquakes as they came, and also with the study of 'historical' earthquakes.

Italy boasted already a long tradition of historical earthquake studies, carried out by several scholars, independently and with different aims and scopes. These 'amateur seismologists' had produced both studies of

single earthquakes and chronological earthquake lists with a local, regional, and sometimes even a worldwide outlook; the late 17<sup>th</sup> century compilation *Terra tremante* [Bonito, 1691], for instance, included earthquakes that occurred in Europe, Asia, and South America. Once Italy had become a single state, it was to be expected that this kind of study re-oriented itself towards evaluating the national seismic potential. The first large-scale historical earthquake compilation published after the unification of Italy [Mercalli, 1883] included a *Saggio di carta sismica*. This was the first attempt at mapping the seismic areas of Italy in four separate time-windows and according to the size and frequency of the earthquakes included in a catalogue compiled by Mercalli himself.

Mercalli [1883] was followed by Taramelli [1886], whose *Carta sismica d'Italia* was based on a catalogue derived from the one by Mercalli [1883], supplemented with information acquired from several lists of historical earthquakes compiled for specific localities/areas by 'friends' of the author (such as T. Bertelli, P. Bettoni, A. Goiran, G. Piovene, and A. Tommasi). Some of these lists were also printed separately in the *Annals of the Meteorological and Geodynamic Office* attached to the Report of the "Royal Geodynamic Subcommittee on the distribution of seismic areas in Upper and Middle Italy", in the year 1888 [Taramelli, 1888].

In October 1894, the UCMG sent out to its nationwide network of 'earthquake observers' and to the main Italian libraries, a circular requesting its recipients to look for information on past earthquakes in their areas of competence and to send back the results. The UCMG historical archives preserve a few of the original handwritten lists of earthquakes dispatched from the towns of Argenta (FE) [Bandi, 1895], Ferrara [Bongiovanni, 1895], Cesena (FC) [Anonymous, 1895], and Fossombrone (PU) [Aiudi, 1895]. Many publications of the last years of the 19<sup>th</sup> century [Agnelli, 1895; Giovannozzi, 1895a,b,c, 1896; Baratta, 1896; 1897, 1899; Chistoni, 1896; Corradi, 1895; Mercalli, 1897a,b and others] can be traced back to the UCMG initiative of 1894 (Fig. 1).

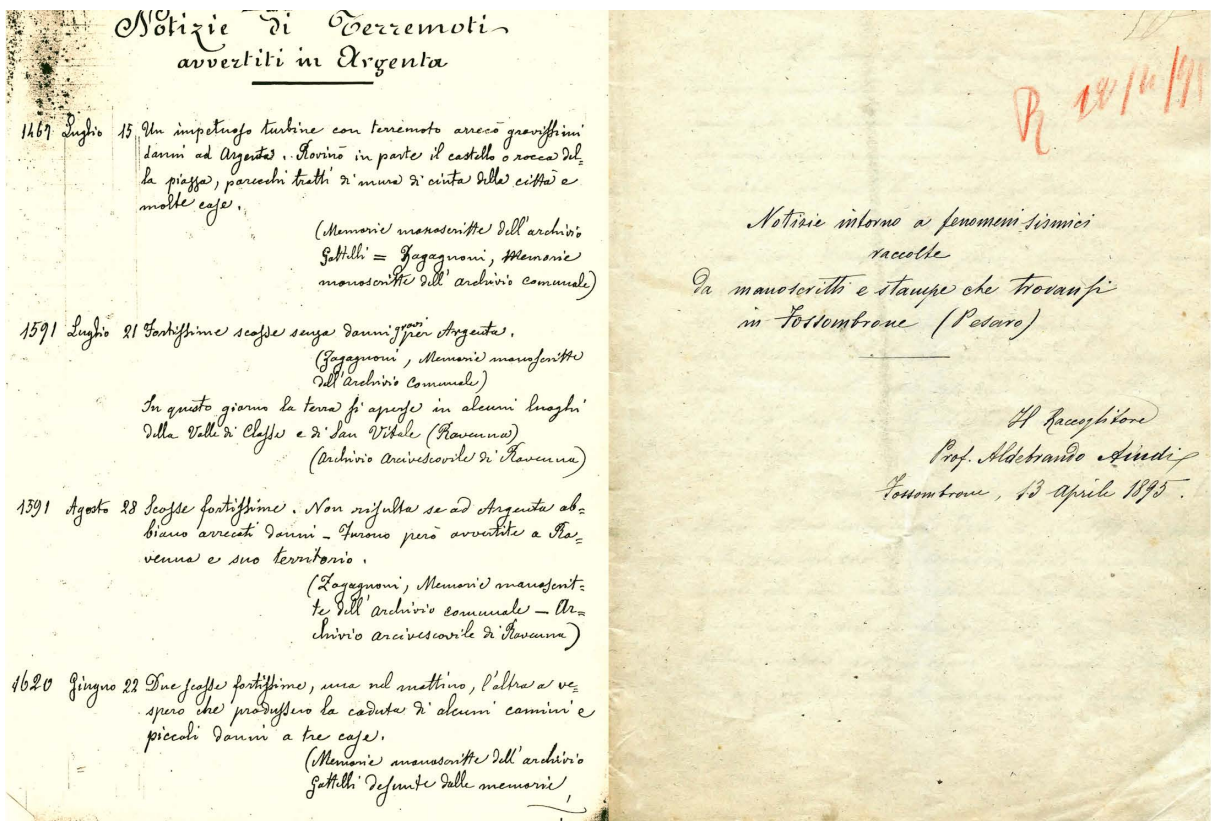


Figure 1. The manuscripts by Bandi (1895) and Aiudi (1895).

The nationwide census of historical Italian earthquakes carried out in response to the UCMG circular of 1894, is one of the main repertories drawn upon by the geographer Mario Baratta (1868-1935) for compiling his monumental treatise *I terremoti d'Italia: saggio di storia, geografia e bibliografia sismica italiana* [Baratta, 1901], together with older earthquake lists, collections of published medieval chronicles, journalistic pamphlets and newspapers of the

## Behind the Italian catalogues: overlooked but far from negligible earthquakes

16<sup>th</sup>-18<sup>th</sup> centuries and seismic bulletins of the late 19<sup>th</sup> century. The use Baratta made of this mass of information was admittedly selective. In other words, he discarded all data related to seemingly ‘minor’, undamaging shocks, keeping only the information on the “major Italian paroxysms” (i.e. those called powerful, very strong, ruinous, and disastrous by seismologists). This selective choice was dictated by his intention of drawing his own seismic map of Italy, in the style of the one produced by Taramelli. Such intention was never to come about, but it is interesting to note that Baratta’s approach was very similar to the one that would be adopted – from the last decade of the 20<sup>th</sup> century onwards – for the compilation of the *Catalogo Parametrico dei Terremoti Italiani* (CPTI), to be used for the construction of Italy’s ‘hazard map’.

In the case of Baratta, however, the decision to discard any seemingly minor earthquakes, entailed the risk of overlooking potentially useful clues and notably influenced the completeness of the parametric seismic catalogues produced in the last thirty years of the 20<sup>th</sup> century, which are based almost exclusively on Baratta [1901] for the whole period between the year 1000 and 1898.

## 2. From descriptive compilations to parametric catalogues

The publication of *I terremoti d’Italia* [Baratta, 1901] had an effect certainly not foreseen by its author: that of dampening the interest in historical earthquake studies for several decades, with the single noticeable exception of Cavasino [1935], who imitated the descriptive scheme laid out by Baratta in his chronicle of Italian earthquakes occurring in the 1900-1933 time-window.

The need for historical raw data on Italian earthquakes arose once again in the last quarter of the 20<sup>th</sup> century, in the frame of the feasibility studies for the selection of sites to host nuclear power plants, promoted first by CNEN (the National Committee for Nuclear Energy, today ENEA), and later on by ENEL (the National Electricity Board) and CNR (the National Research Council). In this context, and also thanks to the clamour following the major 1980 Irpinia earthquake, the CNR Progetto Finalizzato Geodinamica (PFG – Geodynamics Finalised Project) promoted the compilation of the so called PFG catalogue, the first public parametric catalogue of Italian earthquakes [Postpischl, 1985]. The PFG catalogue covered the 1000-1980 time-window and was compiled on the basis of the unpublished ENEL [1978] parametric catalogue, supplemented with a few other national [Carrozzo et al., 1972] and regional [Iaccarino and Molin, 1978, Dell’Olio and Molin, 1980, etc.] catalogues and with a handful of historical studies carried out *ex novo* on particularly important earthquakes (Table 1).

Main Reference	Entries	Percentage
Baratta [1901]	2048	31%
Parametric Catalogues	3718	56.2%
Bulletins	493	7.5%
Others	352	5.3

**Table 1.** Simplified analysis of the PFG catalogue [Postpischl, 1985] (<1900 and  $I_x \geq 4$ ): almost 70% of the catalogue entries are derived from other parametric catalogues, compiled with very different purposes and criteria

A detailed analysis of how the PFG catalogue was compiled would be beyond the scope of this paper, but it should be stressed that the result of this procedure was heavily affected by the inhomogeneity of its input catalogues, which differed widely in terms of the intensity threshold, macroseismic scales and treatment of seismic sequences adopted by each. For some considerations on this aspect see Camassi [2004] and Slejko et al. [2022]. However, for better or worse, the publication of the PFG catalogue laid the foundations for the revival of historical earthquake studies in Italy.

### 3. The late 1900s Italian renaissance of historical seismology

Contextually with the preparation and publication of the PFG catalogue, a new Italian season of historical earthquake research began. Two distinct, but substantially complementary, research teams came into being, and for the first time ever, professional historians were closely involved in it.

The first team, initially financed by ENEL, and later by ING, systematically studied the seismicity of three Italian sectors of Piedmont, Lombardy, and Apulia, selected as possible sites for nuclear power plants. Once the National Energy Plan was dismissed, from 1988 onwards this team settled down to a systematic study of ‘strong earthquakes’, i.e. those included in the PFG catalogue with  $I_0 \geq 8-9$  (*Catalogo dei Forti Terremoti Italiani*, henceforth CFTI). A second team, sponsored by the Gruppo Nazionale per la Difesa dai Terremoti (National Group for Earthquake Defence, henceforth GNDT), worked from 1988 onwards within the frame of the “Progetto Pericolosità” (Hazard Project) [Stucchi, 1993], arranging all the available macroseismic data (including those derived from the CFTI project) and developing systematic historical research on all earthquakes with  $I_0$  “above the damage threshold” included in the PFG catalogue.

### 4. Missing, misplaced, mistaken earthquakes

The whole historical research on earthquakes, from the mid-1980s to now, has its starting point in the compilatory work recorded in the PFG catalogue. For the period earlier than 1899, the PFG catalogue essentially provides information only on such earthquakes as were included in the Baratta [1901] compilation. In other words, the current Italian seismic catalogue [Rovida et al., 2022] still relies largely on Baratta (and, obviously, his sources) for the identification of most pre-1899 earthquakes.

Over the last two decades, a systematic effort has been made to go ‘beyond Baratta’, in order to retrieve historical earthquakes that Baratta and his collaborators had either failed to pick up or that Baratta had discarded on account of their being not relevant enough for his purposes. The retrieval of such earthquakes unknown to or discarded by previous researchers has been made possible, first of all, by a meticulous re-reading of texts from the pre-20<sup>th</sup> century tradition of descriptive seismological studies, supplemented with systematic surveys of serial historical sources (such as newspapers and private diaries). For a progress report on this research, updated to 2011, see Camassi et al. [2011].

In the several stages of this complicated process of source reconnaissance, forgetfulness, loss of information and even outright errors of interpretation are possible and even frequent. Analyses on the historical completeness of catalogues unequivocally show a consistent loss of information even for relatively recent historical periods [Albarello et al., 2001; Stucchi et al., 2004].

This short experience has led to the retrieval of quite a few significant (damaging) earthquakes that had remained totally unknown to what we call the seismological tradition. However, the objective of systematically identifying earthquakes not included in the extant parametric catalogues has never been officially planned and funded in research programmes, because it would have required an impractical commitment and use of resources. Aside from a few episodic contributions [Mariotti et al., 2000; Mariotti and Guidoboni, 2006], the only work with a certain systematic character is the aforementioned Camassi et al. [2011], which was, moreover, carried out by a small group of researchers who worked voluntarily in their spare time.

However, a question needs to be asked at this point: do unknown or forgotten earthquakes, the traces of which have been lost perhaps due to trivial mishaps, still exist?

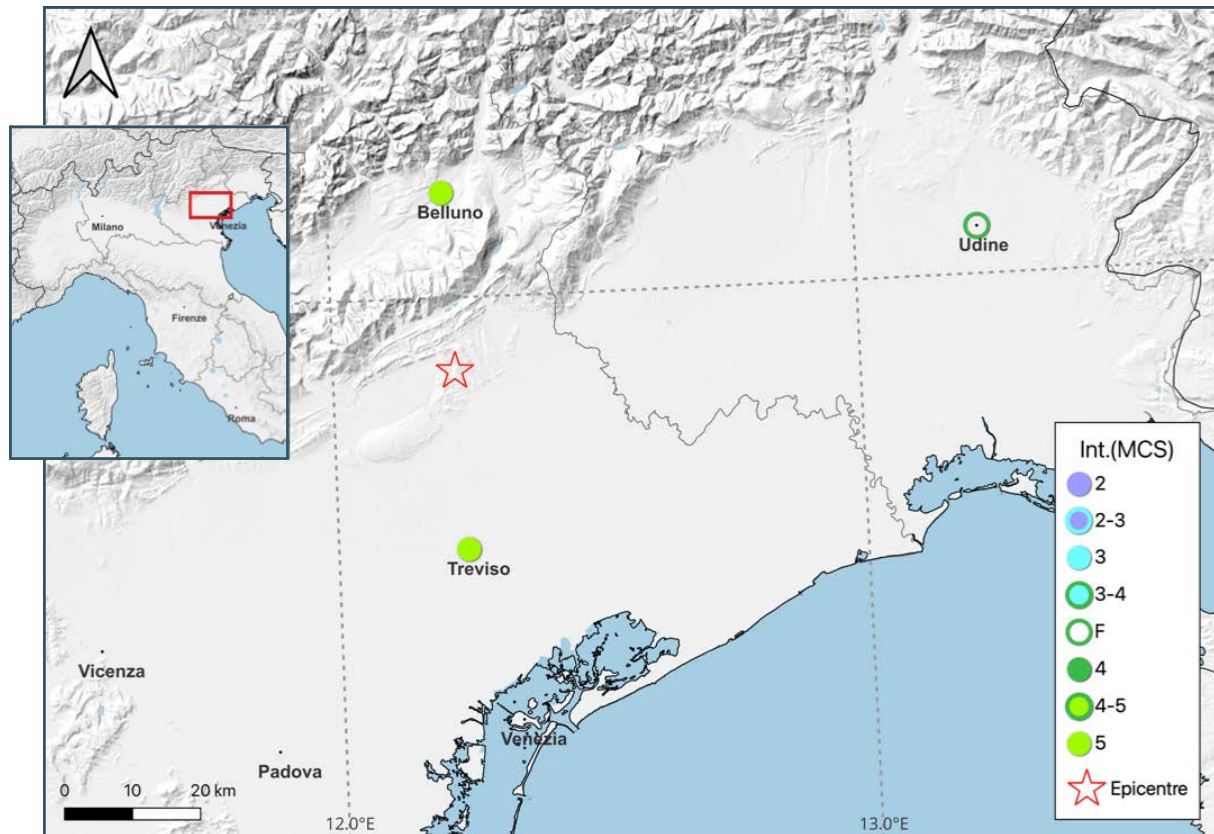
The answer is: yes, definitely, as the following few examples show.

#### 4.1 A discarded earthquake: 3 February 1545 (NE Italy)

The Iaccarino and Molin [1978] regional catalogue listed this earthquake with a conventional set of epicentral coordinates but no epicentral intensity, in order to mark it out as a possibly relevant earthquake and an object for future studies. The Iaccarino and Molin [1978] earthquake record was adopted by Postpischl [1985] but discarded by later catalogues, its lack of an epicentral intensity being interpreted as its being below the damage threshold. Only a careful analysis of the Iaccarino and Molin [1978] references allows us to ascertain that information on

## Behind the Italian catalogues: overlooked but far from negligible earthquakes

the 3 February 1545 earthquake had been derived from Tommasi [1888], a Friulan earthquake compilation whose source was in this case a contemporary report by an eyewitness in Udine. The retrieval of other records of “a great earthquake” felt on the same day in Treviso [Berengo, 1545] and of “a very great earthquake” in Belluno [Piloni, 1607], that can be classified as grade V on the MCS scale, considering the long distance from Udine, suggests that this was a major earthquake, whose epicentral location is uncertain and deserves further investigation (Fig. 2).



**Figure 2.** Intensity map of the 1545 February 3 earthquake. The red star indicates a hypothetical epicentre.

### 4.2 An overlooked earthquake: 8 April 1642 (NW Italy)

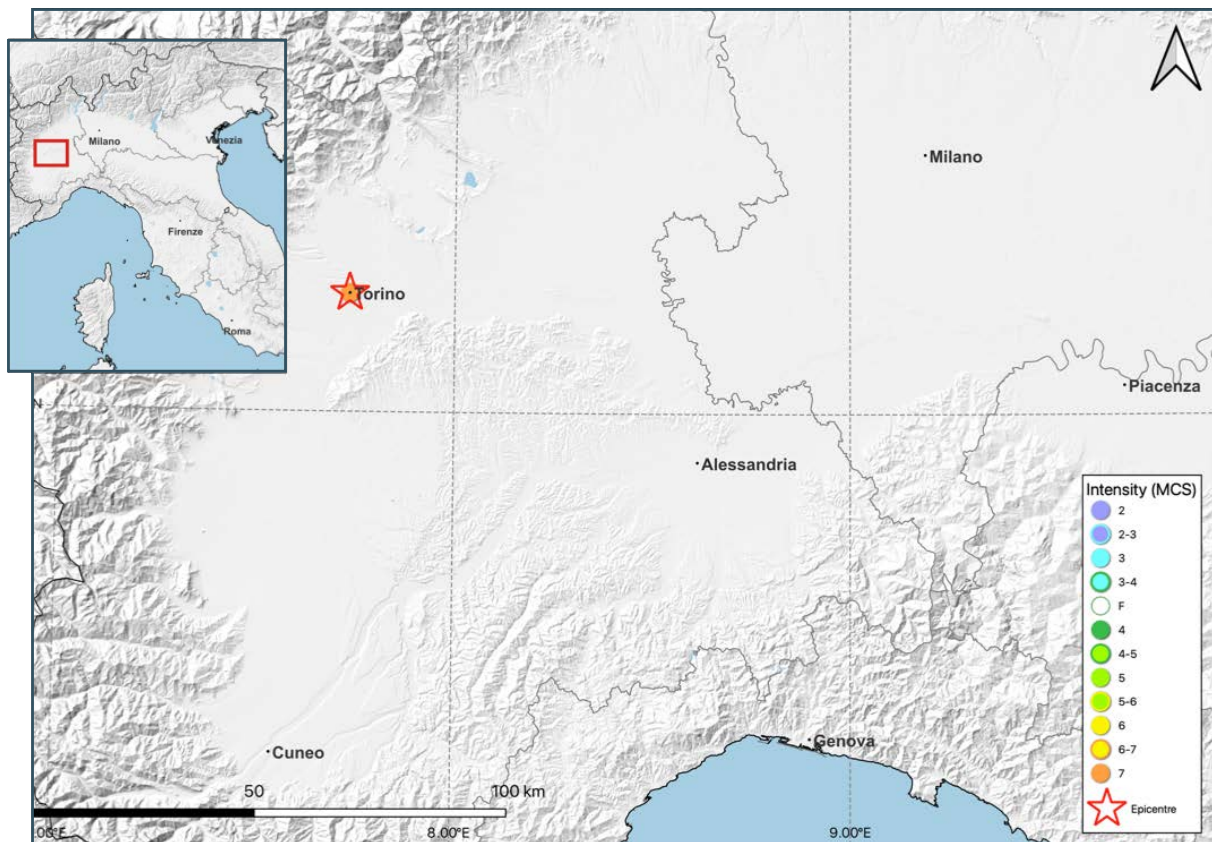
Some 19<sup>th</sup>-century compilations mention an earthquake that, in 1642, was felt in Turin [Mercalli, 1897b] or, generically, in Piedmont [Hoff, 1840; Perrey, 1848]. Mario Baratta, who knew and used these compilations, did not include the 1642 earthquake in his book, probably because no damage was mentioned in connection with it. Accordingly, it was not listed in the PFG catalogue.

The 8 April 1642 earthquake was reinstated as a damaging event, possibly responsible for the highest seismic damage on record in Turin’s seismic history, thanks to a chance finding (Table 2; Fig. 3). According to a contemporary newsletter, written in Milano and currently preserved in the Florence State Archives [ASFI, 1642], this earthquake “caused a thousand chimneys and several houses to collapse” in Turin, the capital of the Duchy of Savoy at the time, a moderate but widespread damage scenario classifiable as Grade VII of the MCS scale. This piece of news was picked up by a few German compilations [Merian, 1643; Dresdner Gelehrte Anzeigen, 1756; Seyfert, 1756] but seems to have been ignored by Italian contemporaries. In fact, to date we have failed to find any corroboration or further details on this earthquake, possibly because it occurred at a very difficult time (the final phase of the Thirty Years’ War), while both Turin and the whole of Piedmont were directly involved in the fighting, during which the city was besieged and bombarded: at such a time, it is possible that the ravage wrought by the war obscured the damage caused by the earthquake, or even that the earthquake, however strong, might have been pushed in the background by more pressing military concerns.

*“Alli 8 stesse, circa le 23 hore, s’intende che nella città di Torino seguisse gran terremoto che durò per poco spatio d’hora gettando a terra più di mille camini con rovina ancora d’alcuni edifitii et no poco spavento di quell’habitanti [...]”.*

Translation: “It is understood that in the city of Turin, on the 8<sup>th</sup> of this month [April 1642], at about 23 hours, there was a strong earthquake, which lasted for a short time but knocked down more than a thousand chimneys, with the ruin of some buildings and no little fear for the inhabitants”.

**Table 2.** The text of the handwritten newsletter reporting the 1642 earthquake [ASFI, 1642].



**Figure 3.** Intensity map of the 1642 April 8 earthquake.

### 4.3 A disregarded earthquake: 8 November 1743 (central Italy)

While the 1642 Turin earthquake had at least been mentioned by a few seismological compilations, none of them picked up another earthquake, that caused moderate damage in Rieti on 8 November 1743.

We are told of it by three journalistic correspondences, written in Rome and printed in the Mantua, Ravenna, and Amsterdam gazettes respectively [(Gazzetta di) Mantova, 13 December 1743; (Gazzetta di) Ravenna, 10 December 1743; (Gazette d’) Amsterdam, 20 December 1743]. Unfortunately, however, Baratta [1901] did not know of this particular earthquake, because his main repertory of journalistic sources [De Rossi, 1889] is based on another Italian periodical – the Bologna gazette – that did not report any news of the 1743 Rieti earthquake. Being ignored by Baratta [1901], this earthquake failed to be included in any of the parametric catalogues of the 1970s and 1980s. Why the Bologna gazette failed to report this particular earthquake remains unclear. True, it seems to have been

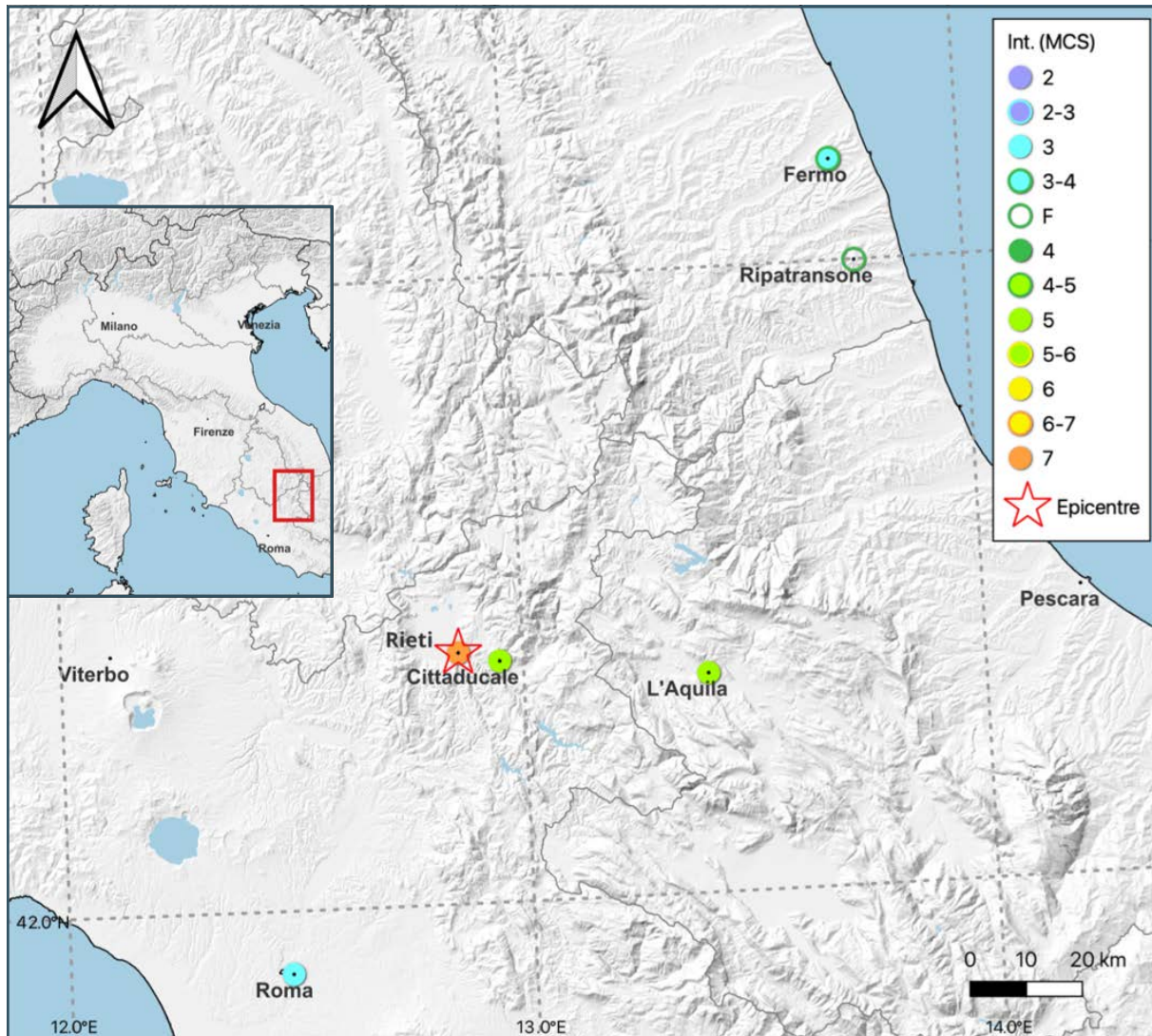


Figure 4. Intensity map of the 8 November 1743 earthquake.

a comparatively minor event, that caused slight damage in a provincial town only. According to correspondence from the gazettes of Mantua and Ravenna, in Rieti the earthquake caused damage to some houses, the cathedral, the bishop's palace, and the municipal building, as well as the fall of numerous chimneys and some injuries: a scenario classified as grade VII MCS. However – as pointed out by entries in some contemporary diaries – the shaking generated was felt in at least three towns placed hundreds of kilometres eastwards of Rieti [Borgia, 18<sup>th</sup> century; Carnili, 18<sup>th</sup> century; Spina, 18<sup>th</sup> century]. So, it is possible that the 8 November 1743 earthquake was more significant than it appears at present: perhaps future research will find out (Fig. 4).

#### 4.4 A misplaced earthquake: 29 September 1808 (NE Italy)

The story of the 29 September 1808 earthquake is similar to that of the 1545 earthquake. The Iaccarino and Molin [1978] regional catalogue includes two records, one conventionally set in Padua, another in Padua-Vicenza, the former lacking an epicentral intensity, the latter with  $I_0$  grade III MCS [Sieberg, 1930], both included just to keep track of events presumed to have been located elsewhere.

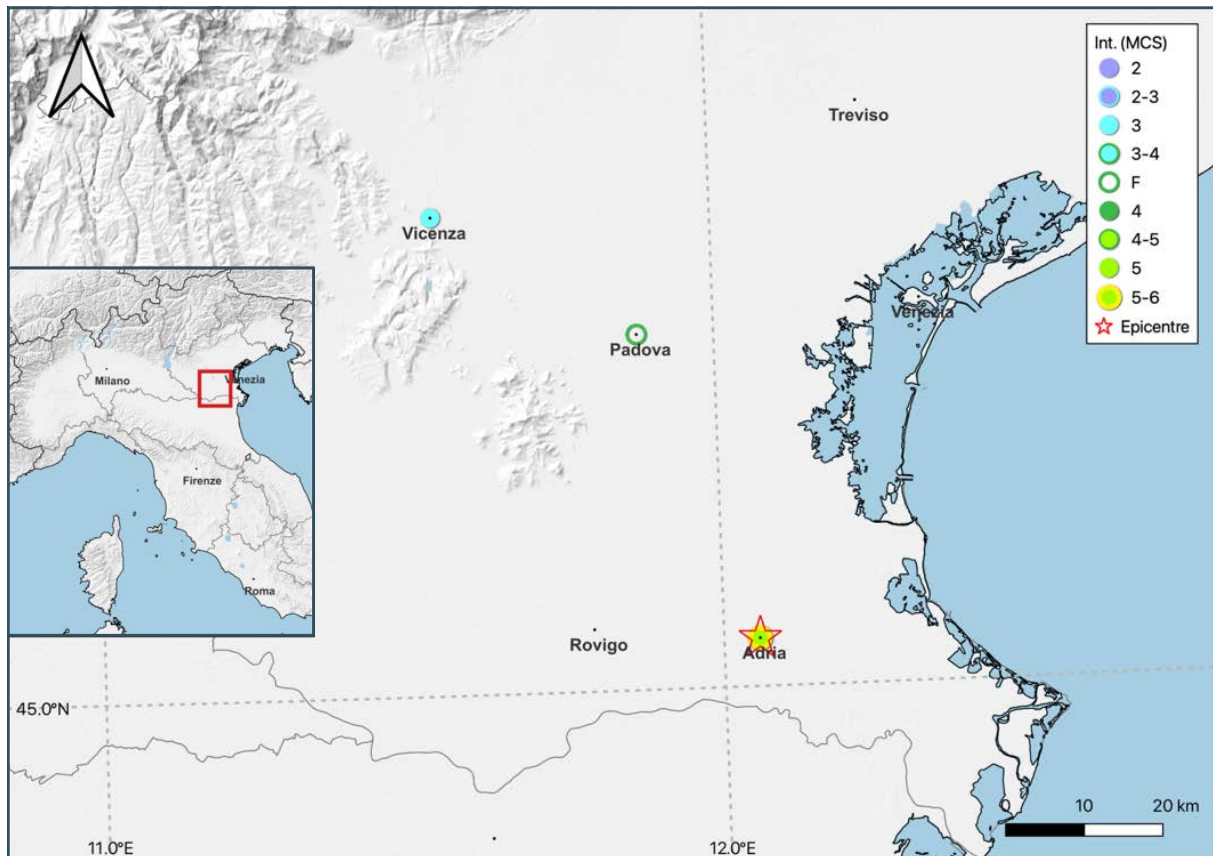
The source for the Vicenza earthquake was Piovene [1888], a local seismological compilation based on a local chronicle [Arnaldi Tornieri, 18<sup>th</sup>-19<sup>th</sup> centuries]. The information on Padua was transcribed from the registers of the Padua Meteorological Observatory by astronomer Giuseppe Lorenzoni (1843-1914), director of the same Observatory, and reproduced in Baratta [1899].

Iaccarino and Molin [1978]									
Date			Time		Coord.		Int.	Ref.	Epic. Zone
1808	9	29	24	–	13.36.63		–	–	PADOVA
1808	9	30	8	–	13.36.65		3	–	VICENZA PADOVA

Postpischl [1985]									
Date			Time		Coord.		Int.	Ref.	Epic. Zone
1808	9	29	24	–	45 25	11 55	–	501	PADOVA
1808	9	30	8	–	45 28	11 42	III	501	VICENZA PADOVA

**Table 3.** Epicentral parameters of the 29 September 1808 earthquake according to Iaccarino and Molin [1978] and Postpischl [1985]. In the ‘Coordinates’ column by Iaccarino and Molin [1978], the codes 13.36.63 and 13.6.65 indicate a generic reference to the Padua and Vicenza-Padua areas (no exact coordinates being available). In the ‘Reference’ column by Postpischl [1985] code 501 indicates Iaccarino and Molin [1978]. The intensity (Int.) is expressed in the MCS scale.



**Figure 5.** Intensity map of the 29 September 1808 earthquake.

## Behind the Italian catalogues: overlooked but far from negligible earthquakes

The Iaccarino and Molin [1978] earthquake records were included in Postpischl [1985] (Table 3), but discarded by later catalogues as likely to be below the damage threshold.

A local chronicle of Adria gives a very tangible record of this earthquake: “[Adria] 29 September 1808. On this morning we felt a great tremor at about eight o’clock in the morning. A few of the chimneys fell. God deliver us from his scourges” [Guarnieri et al., 18<sup>th</sup>-19<sup>th</sup> centuries]. The fact that some damage, albeit moderate (classifiable as uncertain between grades V and VI MCS), occurred at Adria, more than 40 kilometres south-east of Padua, does significantly shift the possible location of this earthquake and confirms the intuition of Iaccarino and Molin [1978] who hypothesized that reports at their disposal were only the trace of earthquakes located elsewhere. In this particular case, it seems likely that the highest damage caused by this earthquake could have been overshadowed by the fact that it affected an area far from the main communication routes and much less important than Padua (Fig. 5).

### 4.5 An earthquake that disappeared: 3 February 1949 (NE Italy)

Finally, here is the singular case of a very recent earthquake – that occurred on 3 February 1949 – that was completely forgotten for several decades, despite having been duly recorded in the seismic bulletins of the Istituto Nazionale di Geofisica [ING, 1949] and of the Osservatorio Sperimentale di Trieste [OST, 1949] and, later on, included in the Iaccarino and Molin [1978] and Bernardis et al. [1978] catalogues.

Both these two catalogues and the ING seismic bulletin were among the sources of Postpischl [1985], but the 1949 event was not included in Postpischl [1985], possibly because of some glitch in the compilation procedure. Thus,

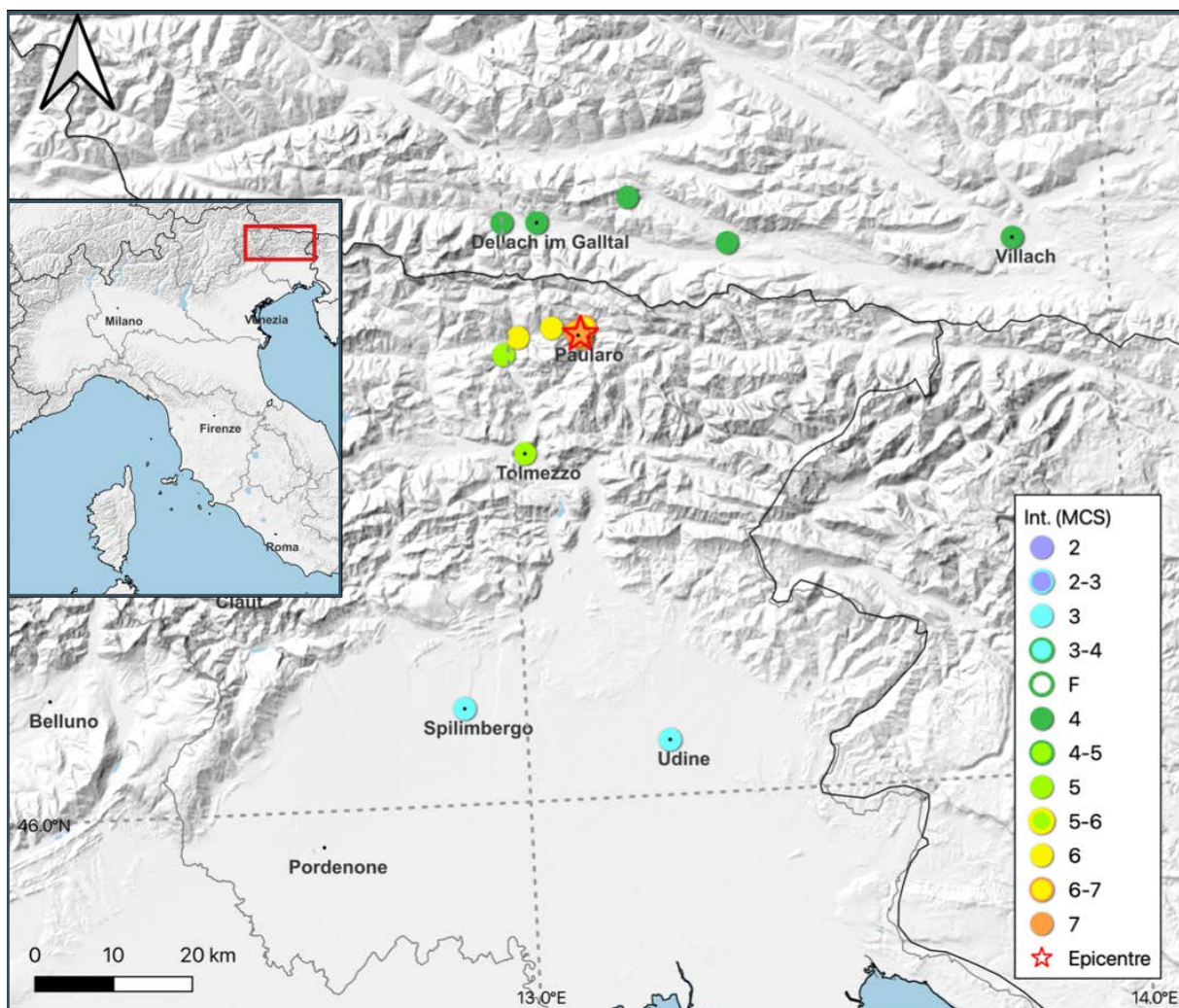


Figure 6. Intensity map of the 3 February 1949 earthquake.

it remained unknown to the later catalogues, until the first version of the CPTI15 catalogue [Rovida et al., 2016] reinstated it as a ‘partial earthquake record’, provided with a date and coordinates derived from Sandron et al. [2014], but with no  $I_{\max}$  or magnitude.

Research on this earthquake was comparatively easy: in addition to the seismic bulletins of the ING and the Trieste Observatory, its impact was extensively described by several Italian and Austrian newspapers. In particular, a regional newspaper [Messaggero Veneto, 5 February 1949] published a lengthy article by one of its field correspondents with detailed information on the effects of the earthquake in the village of Paularo and several other localities, in some cases providing quantitative estimates of damage. According to the technical inspections in Paularo, most of the houses were slightly damaged, 6 were uninhabitable and about 20 were to be shored up, a scenario corresponding to grade VII MCS; in some hamlets of Paularo, uncertain effects between grades V and VI MCS were found. Austrian newspapers [e.g. Wiener Zeitung, 5 February 1949] also provide information on the earthquake being felt in Villach and other places (Fig. 6).

## 5. Conclusions

The margins for rediscovering earthquakes that to date failed to be included in any of the contemporary parametric catalogues are still quite large. It is likely that most of the earthquakes that one can expect to retrieve by adopting this research strategy will be of middling energy ( $4 \leq M \leq 5.5$ ). However, even these middling-energy earthquakes would be of enormous importance to fill in the many gaps still apparent in the seismic histories of numerous Italian localities and to improve/refine our assessment of hazard at a local and subregional level.

The macroseismic data points for all earthquakes reviewed in this study are provided in Table S1-S14 in the electronic supplement to this article.

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## Behind the Italian catalogues: overlooked but far from negligible earthquakes

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