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# Some events in Central Italy: are they all tsunamis? A revision for the Italian tsunami catalog

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**Abstract**
The catalogs available in the literature show that tsunamis affecting Italian coasts are not very strong, except for a few well analyzed events, *i.e.* the Messina December 28, 1908 tsunami. This study aims at making a careful revision of some minor tsunamigenic events, in particular those occurred along the coasts of the Central Tyrrhenian Sea, considering tsunamis associated with earthquakes, from 1700 to 1919. These events have been poorly studied so far, and need a check to verify their reliability, even though they are reported in the catalogs. The results show how it is difficult to get a clear definition of those tsunamis, because of a gap in the historical sources, in spite of the large amount of seismological data concerning earthquakes related to the analyzed tsunamis. This analysis proposes to delete from the catalog some events for which a clear groundlessness appeared.

**Key words** *tsunamis catalog – Tyrrhenian coast – sources revision – reliability*

## 1. Introduction

The interest of the scientific community in tsunamis has recently increased also for the Mediterranean Basin, an area in which the tsunami risk is not as high as in the Pacific Ocean, but nevertheless noticeable. Along Italian coasts the tsunami hazard has been underestimated for a long time, but it has not been neglected.

Disastrous events have occurred in Italy, like the tsunami triggered by the Messina earthquake (December 28, 1908) that, with waves up to 12 metres high, killed hundreds of people who had escaped to the beach. Some other important tsunamis occurred in Calabria (Southern Italy) on February 5, 1783, causing death and destruction, and in Liguria (Northern Italy, 1887), causing anomalous waves in the sea and damage to some vessels. However, most of the tsunamis reported in the Italian catalog are very weak and, generally, not well defined.

At present, for Italian tsunamis just one catalog is available (Caputo and Faita, 1984). This catalog reports a list of 154 events with bibliographical sources, without comments or any other interpretation about the reliability of the data. As for the most of tsunami catalogs available in the literature, the Italian one is not in analytical form and it mainly contains more or less complete historical information. At first sight, analysing the Caputo and Faita (1984) catalog, it would seem that, in the Mediterranean basin, along the coasts of Italy the tsunami hazard is quite high, but a more detailed analysis underlines that the catalog mainly contains minor events: most of them are very doubtful. A recent statistical analysis of the Italian catalog (Di Maro and Maramai, 1992) showed that Italian tsunamis have generally a tectonic origin (56%), rather than a volcanic origin (15%), and only two events have been triggered by

submarine landslides. The remaining 28% do not belong to those categories and, therefore, doubts arise as to whether they are valid items or events of a different nature.

The presence of this large percentage of doubtful sea movements points out the necessity to revise the catalog. Furthermore, it is noticeable that the frequency of events tends to increase up to the XIX century and to decrease in the present century, leaving the catalog largely incomplete in its more recent part (Tinti, 1989). This aspect can be explained by the observational character of the Italian tsunami catalog, that, unfortunately, is exclusively based on qualitative data, instrumental data being completely absent.

As regards the tsunami science, during the last century the practice of direct observation

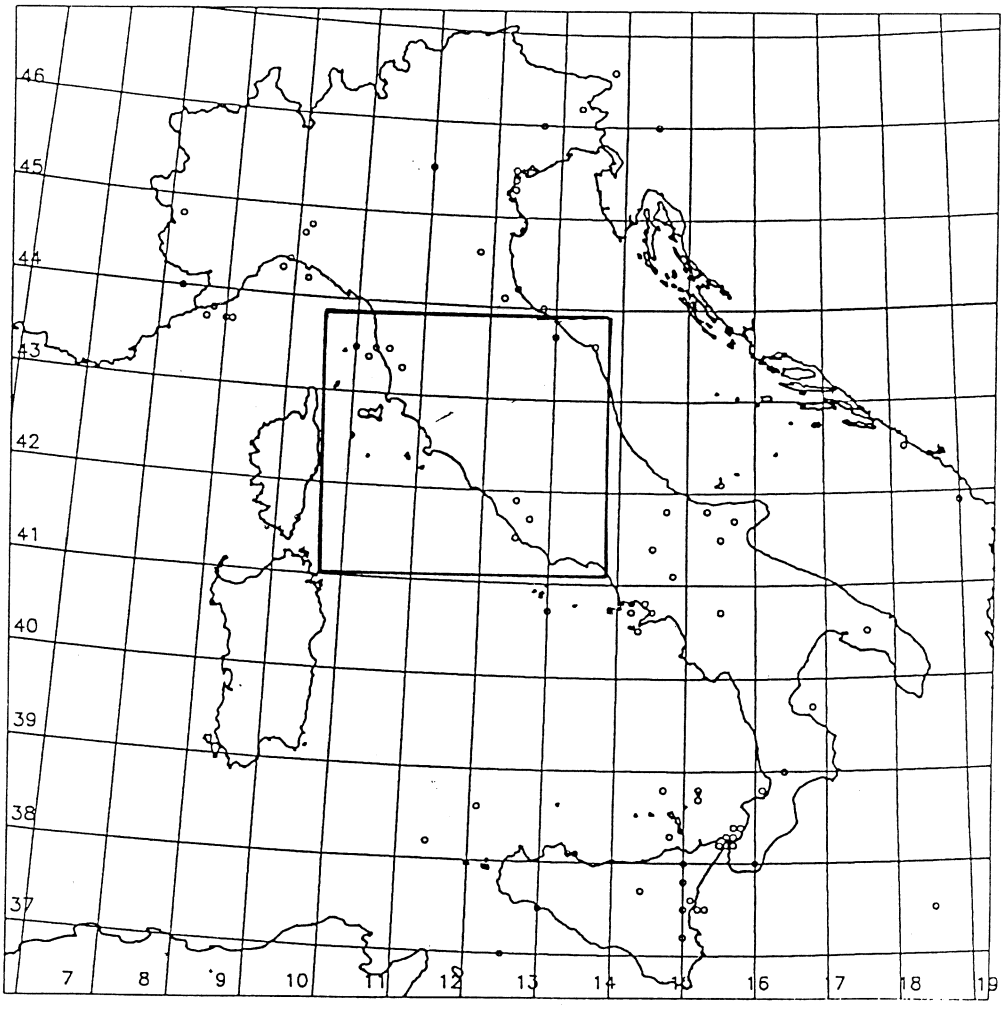


**Fig. 1.** Distribution of Italian tsunamigenic earthquakes from Di Maro and Maramai (1992). The studied area is indicated in the box.

has declined and has not been substituted by instrumental measures, as on the contrary happened in seismology.

To better understand the real tsunami hazard along the Italian coasts, the first phase is to draw up a complete and reliable catalog to permit a serious evaluation of the tsunami phenomena. A large amount of information and sources are available for some of the most important events, which have recently been studied in detail (Tinti and Guidoboni, 1988; Guidoboni and Tinti, 1988). Minor tsunamigenic events, that are the majority in Italy, need to be studied for a better knowledge of the phenomenon, even though this is hampered by a lack of available information. In fact, the lack of instrumental records increases the difficulties in the Italian tsunamis study, especially for minor events, for which the tide record availability is necessary to discriminate between sea movements really due to tsunamis and anomalous sea level oscillations coming from different causes. This paper, in the frame of drafting an analytical catalog of Italian tsunamis, takes into consideration just a few minor tsunamigenic events which occurred along Italian coasts: in particular, two areas in Central Italy have been analysed, Latium and Tuscany, as a start for a revision of the whole Italian tsunami data set. Since the available data to carry out our revision are only qualitative, in this paper we are not able to consider any tsunami wave amplitude and run up values for the studied events.

## 2. Data revision

Starting from the Caputo and Faita (1984) catalog and its updating (Bedosti and Caputo, 1986), a critical revision of the information was carried out. The analysed events concern the coasts of Tuscany and Latium (Central Italy) on the Tyrrhenian Sea (fig. 1). The main feature of those events is the uncertainty of their occurrence, both for the fragility of the information about sea level oscillations and the difficulty of any connection with an earthquake. A recent assessment of the tsunami hazard (Tinti, 1991) showed that the coasts of Latium are not very prone to tsunamis: in fact they exhibit the lowest tsunami rate in all Italy, one tsunami over $10^4$ years. In the same paper the author (Tinti, 1991) calls for a careful reexamination of the reliability of data reported in the Caputo and Faita (1984) catalog.

The seismicity of the Tyrrhenian margin is connected with its extensional tectonic history: in fig. 2 it is possible to distinguish some different clusters of seismicity; in particular the earthquakes located offshore near Pisa and Leghorn (fig. 2) are characterized by events with shallow hypocenter and low energy releases, with effects on the coastal villages that rarely reached VII MCS intensity degree. In the occurrence of the more recent seismic sequence (April 22, 1984, $I$ = V-VI MCS), with estimated magnitude $M_L = 4.2$, no anomalous sea water behaviour was observed. A scattered inland seismicity is also recorded south of Leghorn: in this area the most relevant event occurred in 1846 and reached VIII-IX MCS intensity degree in Orciano Pisano (Albini *et al.*, 1991) (fig. 3).

Southward, the area very close to Rome (including the town of Rome itself) is affected by rare local seismicity that never exceeded effects corresponding to VII MCS intensity degree (Riguzzi and Tertulliani, 1993); besides, about 20 km south-east of Rome, the well known volcanic complex of Colli Albani is an important seismogenetic area, with a frequent shallow swarms activity, hardly exceeding magnitude 4.0.

Along the coast south of Rome, just one remarkable event is reported: the Anzio earthquake that occurred on October 22, 1919 ($I_{max}$ = VII – VIII) that is the only one for which instrumental data are available. The last group of earthquakes shown in the map occurred in the sea and is related to the Pontine Islands, a Pleistocenic volcanic complex settled on the continental slope, located offshore in front of C. Circeo and Gaeta. In this area all events are very weak, the maximum having been reached during the 1781, April 13 earthquake, with intensity VII MCS felt in Ponza.

It is necessary to underline that the above described seismic activity of the Tyrrhenian coast did not cause anomalous sea movements

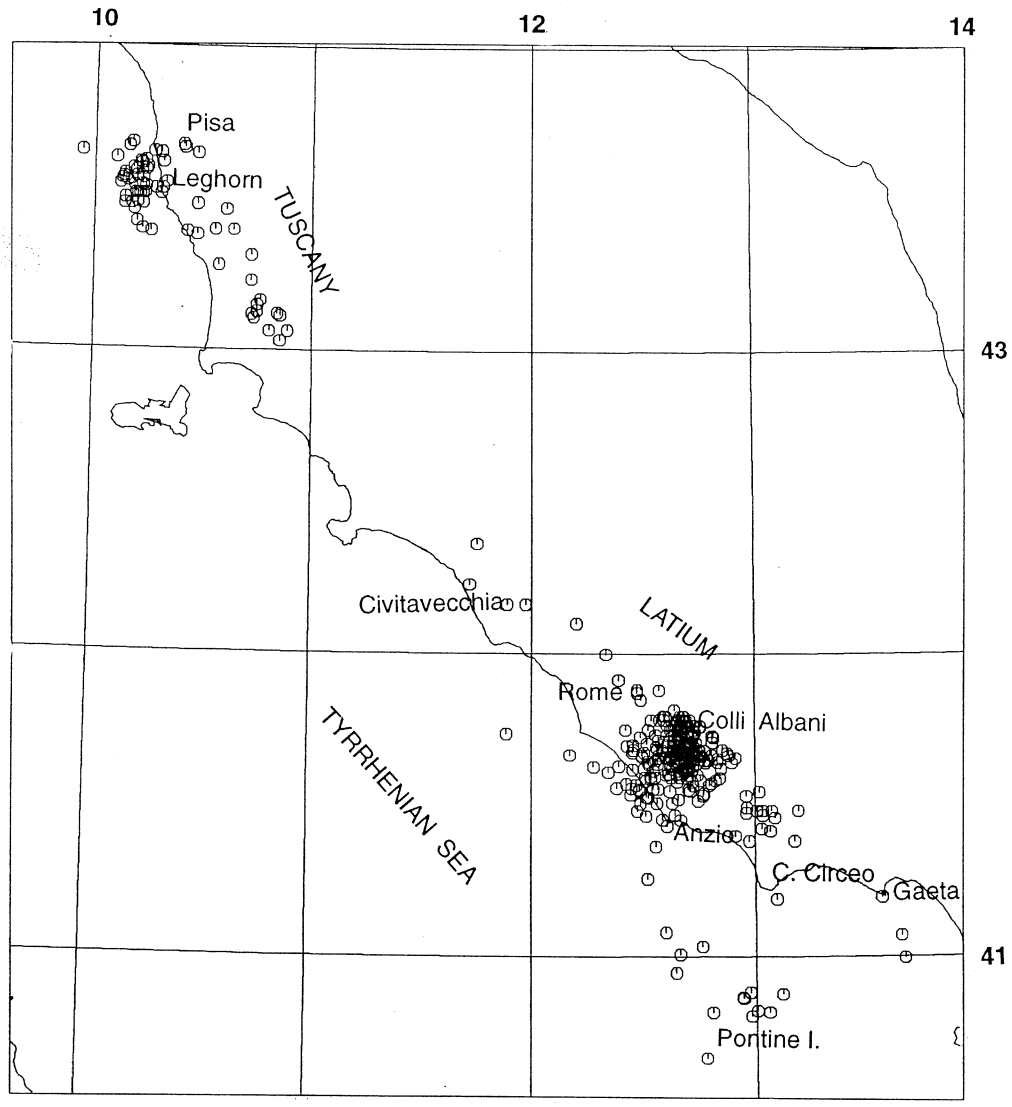


**Fig. 2.** Seismicity of the Tyrrhenian coast of Italy, from ING seismic catalog for $I \geq$ III and $M_L \geq 2.4$.

except for the seven cases studied in the present paper. In our revision we took into consideration the 1703, 1742, 1806, 1846, 1892, 1895, 1919 events which occurred along the Latium and Tuscany coast (fig. 3), reported in the Caputo and Faita (1984) catalog as tsunamis.

During the study, the proposal to prepare a new analytical catalog divided into at least two parts emerged. One part collecting real tsunamis, that is all those events for which reliable information on significant phenomena are available; the second part concerning anomalous sea level oscillations of unknown origin, that could not be classified as tsunamis but that could not be ignored completely.

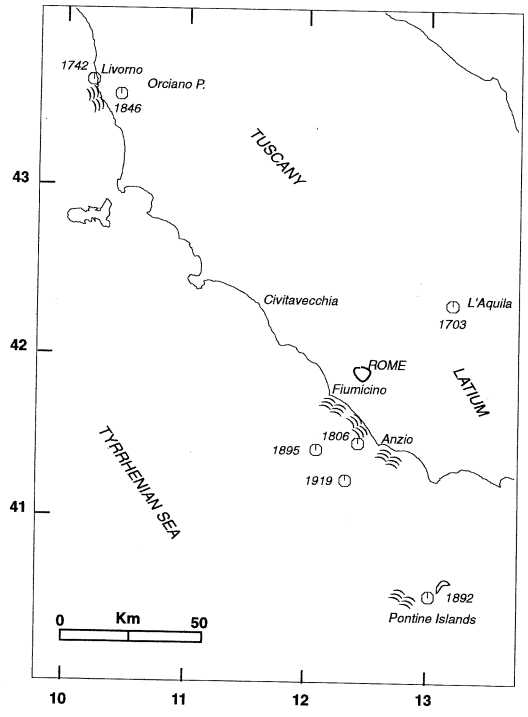


**Fig. 3.** Location of the events considered in this paper, as from Caputo and Faita (1984). Circles are from the references earthquake, waves are for the coasts affected by tsunamis.

## 2.1. *Events description*

*February 2, 1703* – Reference earthquake (Caputo and Faita, 1984): $\phi = 42.27$, $\lambda = 13.20$, $I_0 = \mathrm{X} - \mathrm{XI}$ (the macroseismic scale of the epicentral intensities is never indicated in the catalog).

The information reported in the Caputo and Faita (1984) catalog for this event is just a weak withdrawal of water at the mouth of the Tiber river near Rome, as referred to by several authors (Mallet, 1854; Mercalli, 1883; Baratta, 1901; Moreira, 1974). The related earthquake occurred on February 2, 1703 at L'Aquila (Central Apennines) causing very severe damage and casualties in the whole region. The epicentral area was located inland about 100 km away from the Tiber mouth. Going back to coeval sources, the belief that the link between the earthquake and the tsunami is a casual one is reinforced. This hypothesis is supported by the fact that the information about the withdrawal is only reported by Baglivi (1704): «*...at the time of the second shock they say that the latin sea at the mouth of the Tiber river near the harbour, receded away from the shore just for a little; after the earthquake the water immediately came back*». None of the other coeval authors, as shown in fig. 4, referred anything about the sea regression. Figure 4 shows the path followed in sources investigation. Concluding, the distance from the epicentre and the lack of direct testimony, leaves many doubts on the reliability of the effects in the sea.

*January-February 1742* – Reference earthquake: not reported in the Caputo and Faita (1984) catalog.

It is difficult to understand why the catalog's authors do not quote the reference earthquake related to the anomalous behaviour of the sea, as the catalog is particularly rich in sources, both coeval and successive, describing in detail the earthquake itself. Other sources have been found in our research completing the feature of the phenomena. Original sources are mainly documents, letters, relations and reports to local Authorities about the seismic period which occurred in Leghorn (VIII MCS). Many direct testimonies (fig. 5) of the event (Pedini, 1742; Gentili, 1742; Anonimo, 1742; Mattei, 1745; Boccacci, 1842) document the anomalous behaviour of the sea during the days 19th, 20th and 27th of January. A sudden rising of waters, some unexpected waves and the increase in the sea level flooded the caves located near the city canals. From the whole reading of the sources and from an analysis of the macroseismic field, it emerges that the epicentres could have been located offshore, quite near to Leghorn where a well known active seismic center exists (fig. 6). In conclusion, the results of the study confirm a relation between the seismic period of 1742 and the concomitant observed effects in the sea.

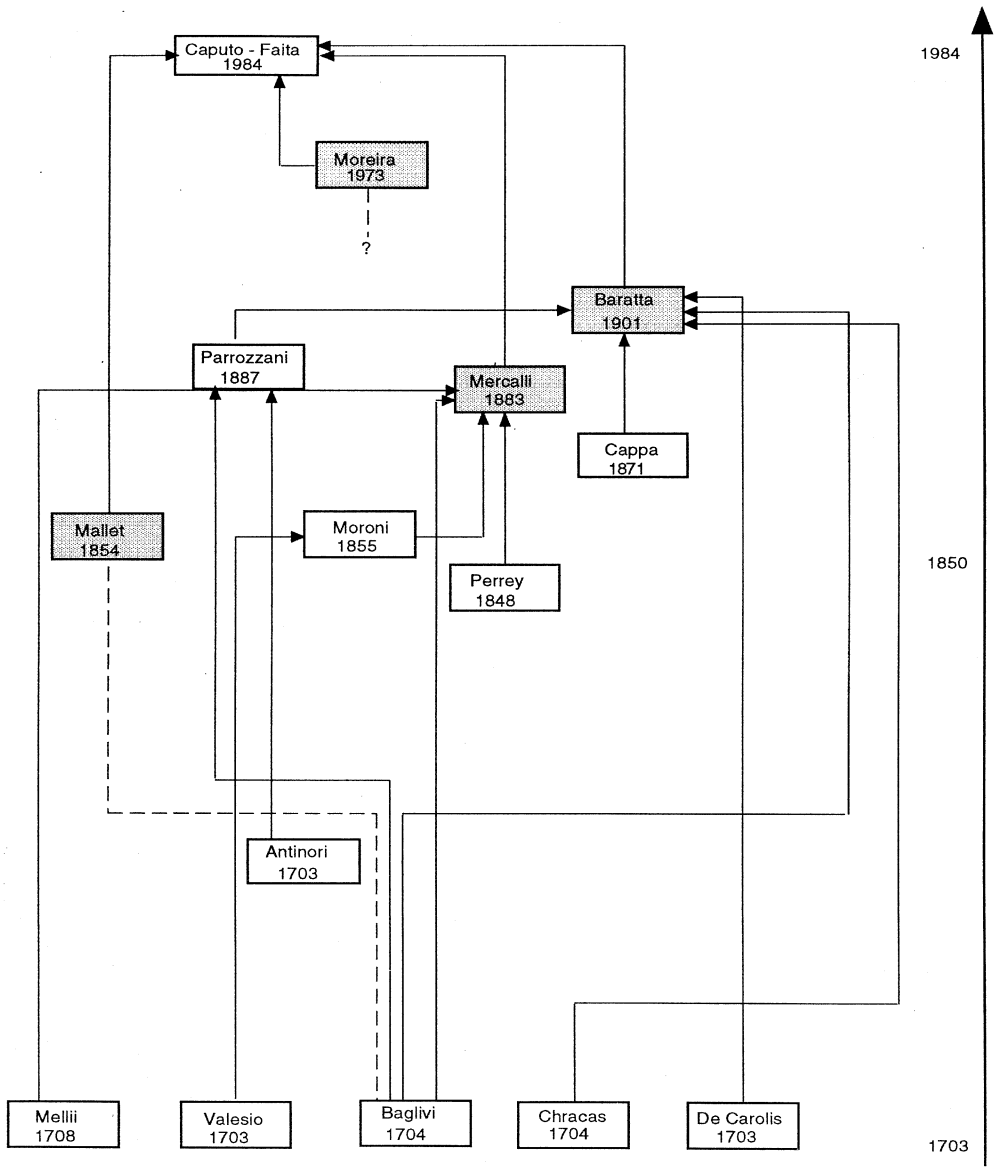


**Fig. 4.** Scheme of the path followed in the sources investigation for the February 2, 1703 event. Other sources used not indicated in the text, are: Antinori, 1703; De Carolis, 1703; Chracas, 1704; Mellii, 1708; Perrey, 1848; Moroni, 1855; Cappa, 1871; Parrozzani, 1887; Valesio, 1977. Among the five sources coeval to the earthquake, only Baglivi (1704) reported the quoted information about withdrawal. The grey boxes are the sources indicated in Caputo and Faita (1984). The dashed line indicates that, probably, the information cited by Mallet (1854) is from Baglivi (1704).

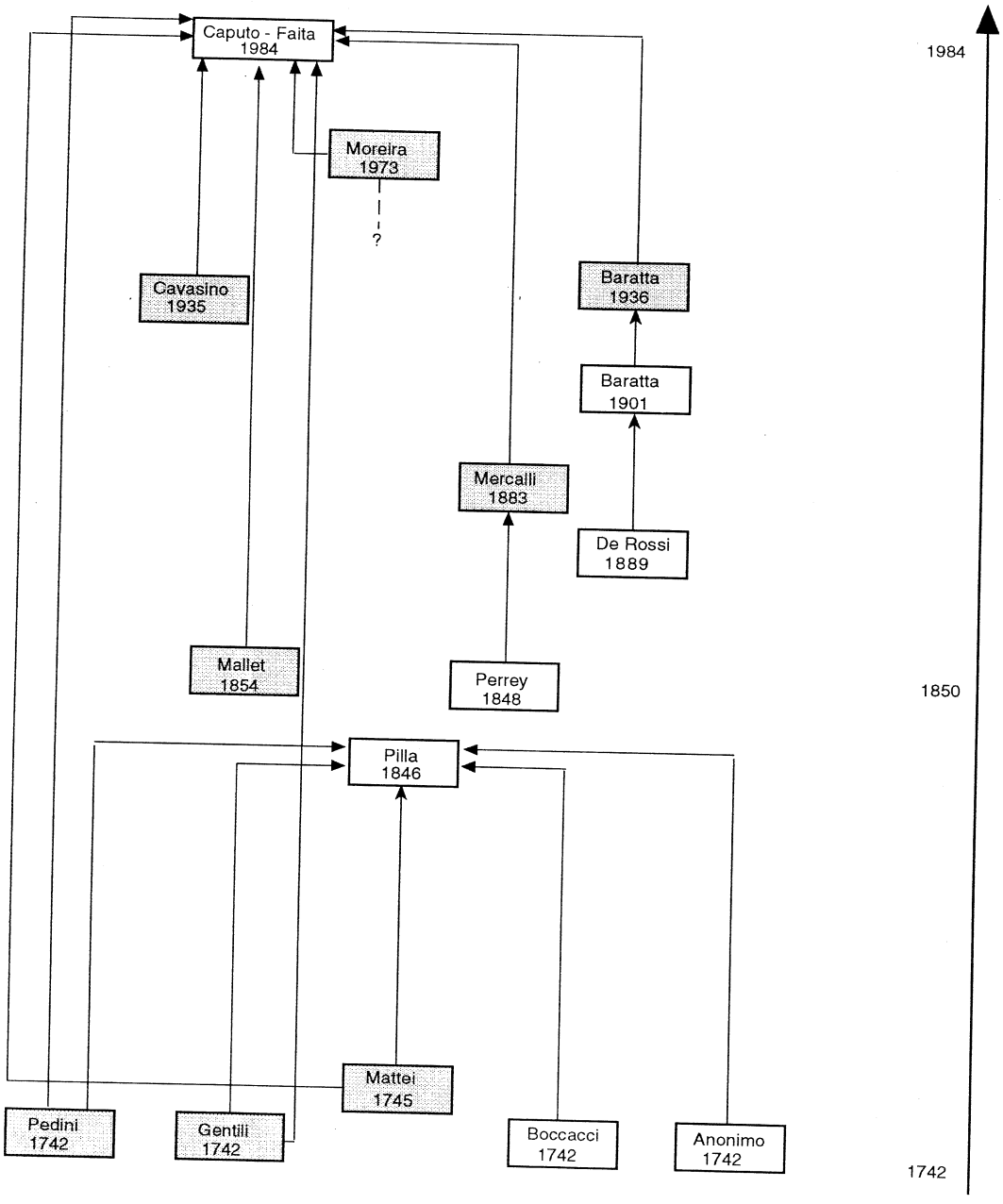


**Fig. 5.** Scheme of the path followed in the sources investigation for the January-February 1742 events. Other source not indicated in the text is Perrey (1848), Cavasino (1935) and De Rossi (1889). The grey boxes are the sources reported in Caputo and Faita (1984).

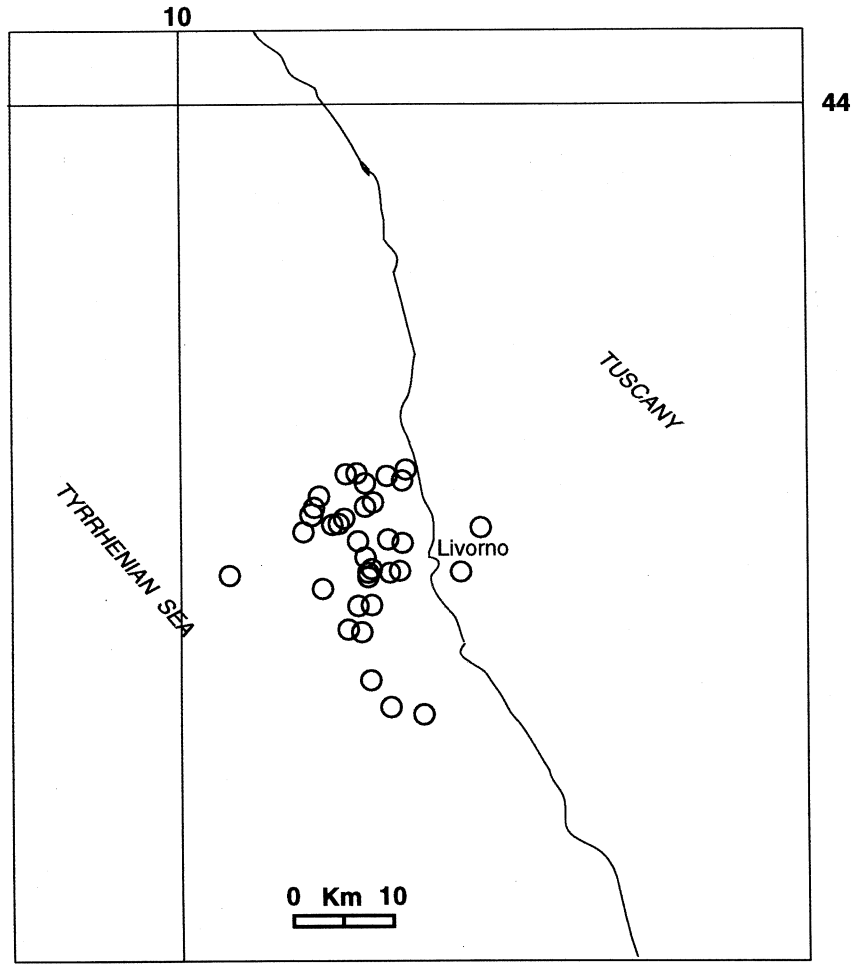


**Fig. 6.** Last 100 years of seismicity in the Leghorn area, from ING seismic catalog.

*August 26, 1806* – Reference earthquake (Caputo and Faita, 1984): $\phi = 41.45$, $\lambda = 12.45$, $I_0 = \text{III}$.

The mark earthquake occurred in the Colli Albani area, about 30 km SE of Rome, and was felt in Rome too.

The epicentral intensity reported in the Istituto Nazionale di Geofisica (ING) Seismic Catalog is VIII MCS while the intensity III indicated in the Caputo and Faita (1984) catalog is probably a mistake. The quotation of the effect in the sea reported in the Caputo and Faita (1984) catalog, comes from Baratta (1897, 1901) who, in turn, got this information from Gilii (1807) who wrote: «*...the sea appeared extremely agitated and stormy on the above mentioned shore...*». Other sources dealing with that earthquake (Bauco, 1851; Giorni, 1842) did not mention any anomalous sea movement that would have happened on the coast immediately south of Rome. This information, even if collected in a meteorological bulletin, is not supported by other quantitative observations, and the original source is un-

known. Furthermore, for the frequent earthquakes occurring in the Colli Albani area, no notice about sea level oscillations along the Latium coasts has ever been reported. As a consequence of these facts, we believe that the connection between the two events is fortuitous, suggesting this quotation should not be inserted as a tsunami in the new analytical catalog.

*August 14, 1846* – Reference earthquake (Caputo and Faita, 1984): $\phi = 43.30$, $\lambda = 10.30$, $I_0 = X$.

This earthquake, recently reclassified as IX-X MCS (Albini *et al.*, 1991), occurred inland about 15 km SW of Leghorn, causing severe damage in some villages. For this event, the Caputo and Faita (1984) catalog lists a few sources that refer to anomalous behaviour of the sea. In particular, Baratta (1901, 1936) refers: «*...unusual sea level oscillations...*» some days immediately before and after the earthquake. The force of the wind blowing at that time cannot explain this kind of phenomenon. Another bibliographical source reported in Caputo and Faita (1984) is the paper written by Savi (1846) that gives a detailed account of the sea's behaviour, beginning on August 11, 1846. In fact, the author says that on that day the sea surged quickly for about two minutes so that people who were swimming ran out of the sea terrified. The sea level oscillations increased on August 14 and during the quake the sea rose more than a yard and some vessels felt a violent shock. After the earthquake, the sea was rough for a few days.

During our study, a thorough research in archives and lending libraries showed a lot of papers, reports and letters on the August 14, 1846 earthquake. Some of them contain detailed information about anomalous phenomena which occurred at the sea, *i.e.* the sudden displacement of ships that were steering towards the port of Leghorn (Tellini, 1846).

The paper of Pilla (1846) includes a specific chapter about phenomena that followed the earthquake. In that chapter the keeper of the Leghorn lighthouse says: «*...water rose near the Tower and, after that, the quays were washed*». In addition, Pilla (1846) quotes some information coming from a few sailors that were on their ship in the harbour: they clearly felt violent knocks in their ships.

Consequently, we think that the above mentioned phenomena must be taken into consideration since they are supported by quite a large number of coeval sources. In our opinion, a connection between the anomalous sea movements and the earthquake is likely enough, although this earthquake had low energy and was located in land. In the same area of the 1846 earthquake, an analysis of the Italian seismic catalog showed that other relevant events occurred, but they never reached the same intensity values as the 1846 earthquake. For the events that occurred during this century, in 1914 and 1950, respectively of VI and VII MCS intensity, not even one observation about sea level oscillations is mentioned.

*November 16, 1892* – Reference earthquake (Caputo and Faita, 1984): $\phi = 40.54$, $\lambda = 13.00$, $I_0 = IV - V$.

The reference in the catalog is related to the seismic period of November 1892 which occurred in the Pontine Islands (Central Tyrrhenian Sea), which suffered slight damage. The information about sea movements was reported by Mercalli (1883) during a survey he performed on these islands after the seismic sequence, and it is related to «a *strong shock experienced by a boat like it had bumped against a rock*». (Mercalli, 1883). A quick examination of the seismicity of the area studied shows that it is usually low and local; no other earthquakes which have occurred in that zone have been linked to tsunami effects. Some anomalous behaviour of the sea near Ponza and Ventotene Islands was experienced by the crews of many boats just during the occurrence of the 1805, July 26 strong earthquake in the Southern Apennines.

Also for the 1892 event, like those mentioned above, we only have one piece of information and it is not supported by any other data, either quantitative or qualitative, as it could have been in an archipelago with harbours and landing places.

The single information about the anomalous behaviour of the sea remains too weak to be

considered a tsunami event related to an earthquake.

*November 1, 1895* – Reference earthquake (Caputo and Faita, 1984): $\phi = 41.41$, $\lambda = 12.12$, $I_0 = \text{VII}$.

The shock related to this event is the one which occurred near Rome, with a maximum intensity of VII MCS south of the city. The quotation of this tsunami in the catalog (Caputo and Faita, 1984) is based on a piece of information coming from Baratta (1901) who collected some news about «*...a rough sea near Fiumicino and the fishes missing along the coast...*». The tsunami hypothesis was supported at that time by several authors (Baratta, 1901; Tacchini, 1895; Galli, 1906; De Rossi, 1897; Agamennone, 1924) who suggested an off-shore location for the earthquake. On the contrary, the Coast Guards of Civitavecchia and Anzio (respectively northward and southward of Fiumicino) who were consulted on purpose, did not notice any anomaly in the sea's behaviour. A recent paper (Riguzzi and Tertulliani, 1993) shows that the epicentre of the November 1, 1895 earthquake was inland, and, besides, the coastal villages sufferred minor damage. In conclusion, the consistence of the tsunami occurrence appears too weak to be inserted as a record in the new tsunami catalog.

*October 22, 1919* – Reference earthquake (Caputo and Faita, 1984): $\phi = 41.23$, $\lambda = 12.35$, $I_0 = \text{VII} - \text{VIII}$.

An earthquake VII-VIII MCS intensity degree struck the coast of Latium near Anzio and Nettuno, South of Rome, and it was felt in a large area. The epicentral location obtained using data coming from 10 seismic stations, was $\phi = 41.370\text{N}$, $\lambda = 12.230\text{E}$, about 40 km offshore in front of Anzio, with a magnitude of $M_L = 5.2$ estimated as average value of the stations themselves. The Caputo and Faita (1984) catalog takes information from Martinelli (1923) who described in detail the observation, directly surveyed in the field. Many descriptions reported by sailors concerned bumps in the hulls and anomalous waves which frightened the crews of some fishing-boats offshore. In addition, boats in the harbour suffered the same phenomena, as reported by some newspaper. On the contrary, the information requested by the Ufficio Centrale di Metereologia e Geodinamica (at that time responsible for seismic studies) to the local authorities about possible anomalous sea movements, were negative. In spite of this discrepancy in the information, we could not exclude a possible correlation between the sea's effect and the strong earthquake occurred offshore.

## 3. Conclusions

In this phase of the revision of the Italian tsunami catalog, some events located along the Tyrrhenian coasts (Central Italy) have been examined. In fact, the coastal areas of Tuscany and Latium seem to be affected by many doubtful events that need a careful re-evaluation. The main difficulties for the study of those tsunamis lie in their low energy: the analysed areas are characterized by a low seismicity, both for frequency and maximum magnitude of events; in addition, the available data are often only indefinite descriptions of anomalous phenomena. In general we can affirm that for the Italian area, except for a few well defined zones (*i.e.* the Messina Straits), we do not find the «classical» conditions for the tsunami occurrence. Besides, a lack of instrumental data availability exists, due to the fragmentation of institutes and authorities devoted the data collection up to now.

In this paper the revision of tsunamis has pointed out the inconsistency of some of them and the real occurrence of only a few tsunamis. About some other events there is still some doubt that they are anomalous phenomena whose association with an earthquake is not clear but we cannot ignore their occurrence.

Another characteristic aspect which emerges is the simultaneous occurrence of sea motions with earthquakes located inland. There is little literature on this topic, because these events happen so rarely. The hypothesis of a propagation of the surface deformation of the generating structure to the sea bottom (Tinti, 1991) does not seem to be in agreement with the

modest size of those Italian earthquakes. In fact we know that if the threshold magnitude to trigger a tsunami is about 7, to propagate a deformation for tens of kilometres would need an earthquake of comparable energy. Those conditions have not been verified for the studied events. However, we could affirm that the observation of some phenomena at (or immediately after) the occurrence of an earthquake, could simply be a consequence of the seismic wave propagation.

Concluding, we confirm the poor tsunamigenic potential of the Latium coast and we propose to exclude from the catalog records the 1703, 1806 and 1895 events. The quoted tsunamis of 1742, 1846 and 1919 are likely to be linked with the reference earthquakes. For the 1892 event there is not sufficient information to define its characteristics. The doubt also remains for all observations of anomalous effects which are difficult to understand; this kind of information should be collected in a second section of the catalog.

This part of the revision of the Italian tsunamis catalog should be completed for the whole Italian peninsula, to define the real features of the tsunami-hazard more objectively and finally to provide a reliable data set.

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