ISSN 2039-6651
Anno 2015_Numero 27

miscellanea INGV

Abstracts Volume 6th International INQUA Meeting on

Paleoseismology, Active Tectonics and Archaeoseismology

19 | 24 April 2015, Pescina, Fucino Basin, Italy

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Sede legale: Via di Vigna Murata, 605 | Roma

ISSN 2039-6651
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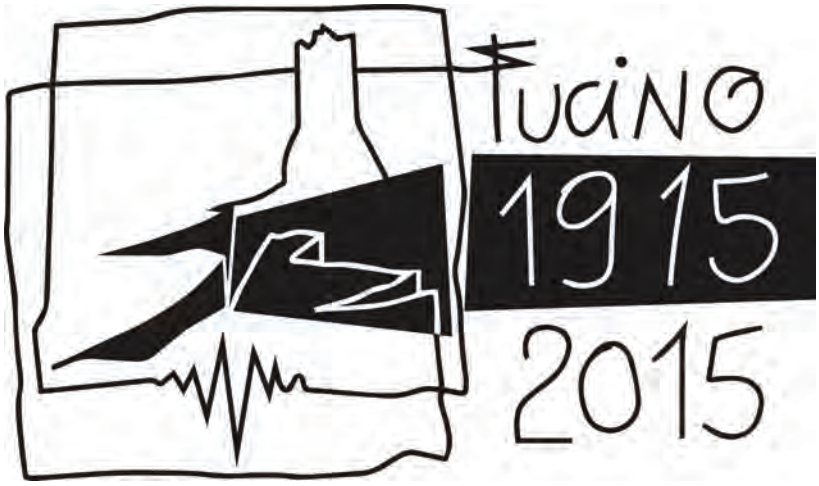

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A contribution to seismic hazard assessment of the Salento Peninsula (Apulia, Southern Italy)

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Abstract: *The aim of this study is a critical revision of historical and recent seismicity of the Salento peninsula (Apulia, Southern Italy), offering an updated evaluation of its seismic hazard currently underestimated. This area is actually included in the least dangerous IV category of the Italian seismic classification. The Salento Peninsula was struck by the February 20, 1743 earthquake, considered as the strongest seismic event of this area. The reassessment of both the macroseismic effects on man-made structures, and the triggered effects in the natural environment has been carried out on the basis of archival documents and recent literature, according to the MCS and the ESI 2007 scale. The main result of our study has been the re-evaluation of the maximum intensity (Imax=XMCS) of the 1743 earthquake, besides new intensity values for some localities along the Apulian coasts.*

Key words: *Salento, 1743 earthquake, ESI 2007 scale, historical seismicity, seismically-induced effects, instrumental seismicity.*

INTRODUCTION

The geodynamic framework of the Apulian area is characterized by the subduction of the Ionian slab beneath the Calabrian Arc; such compressive regime is still active (Caputo et al., 1970; Castello et al., 2006).
The Salento peninsula (Apulia, Southern Italy) is considered the stable foreland of the Southern Apennines chain (Cinque et al., 1993, Gambini & Tozzi, 1996), although it has been epicentral area of several earthquakes over the last centuries with magnitude $3 \leq M_w \leq 5$, apart from the February 20, 1743 earthquake with M_w=7.1 (CPTI11, Rovida et al., 2011).
This area is also affected by significant seismicity of the surrounded regions: to the east the coast of Albania and the Ionian Islands (western Greece); to the west the Calabrian arc and the Southern Apennines chain (Fig. 1).
The Salento area is actually included in the least dangerous IV category of the Italian seismic classification (http://www.protezionecivile.gov.it/resources/cms/documents/A3_class20140605.pdf).
The main goal of this paper is to provide a contribution to the Salento seismic hazard evaluation through the following investigations:

- Analysis of historical and recent seismicity from available catalogues of the Apulia region and particularly of the Salento peninsula;
- Analysis of historical and recent seismicity of the Salento surrounding regions (Adriatic and Ionian sea, Albania and Greece) in order to identify the seismoinduced effects in the Salento area;
- Identification and evaluation of earthquake environmental effects of the February 20, 1743 earthquake from archival documents and scientific papers;
- Macroseismic revision of the February 20, 1743 earthquake according to the Mercalli-Cancani-Sieberg scale (MCS) and to the Environmental Seismic Intensity scale (ESI 2007) (Michetti et al., 2007; Guerrieri et al., 2012).

DATA ANALYSIS

The historical and recent seismicity in the Apulia region is characterized by a greater frequency of earthquakes in the northern sector compared to the southern one (Fig. 1).

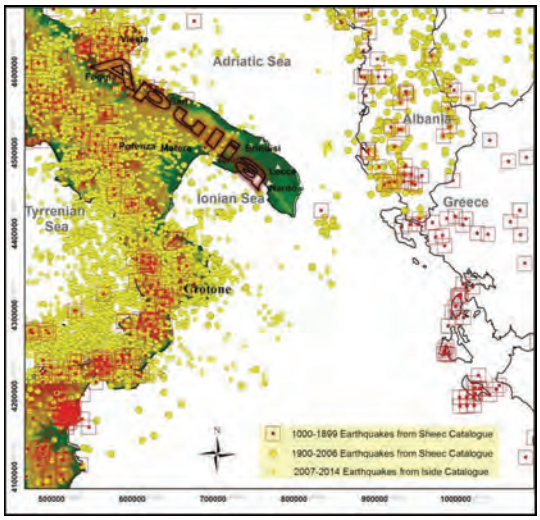

Figure 1: The map shows the spatial distribution of historical and recent seismicity extracted from: CPTI11 (Rovida et al, 2011) and SHEEC, (Stucchi et al., 2013; Grünthal et al., 2013).

Over the last centuries, the Apulia region from Gargano to Salento has been affected by significant earthquakes (Fig. 2), the most important of which have been extracted from the seismic catalogues CPTI11 (Rovida et al., 2011) and SHEEC (Stucchi et al. 2013; Grünthal et al., 2013), and occurred in:

- 1087 (I=VI-VII MCS, Bari);
- 1560 (I=VIII MCS, Barletta-Bisceglie);
- 1627 (I=X MCS, Gargano);
- 1731 (I=IX MCS, Foggia);
- 1743, (I=IX MCS, Ionian sea);
- 1826 (I=VI-VII MCS, Manduria);
- 1889 (I=VII MCS, Gargano);
- 1909 (I=VI MCS, Nardò).

According to the above mentioned catalogues, the 1743 earthquake epicenter is located in the Ionian sea, but the maximum intensity refers to some localities on land.
The instrumental recent seismicity of the Salento peninsula is mainly concentrated around the Strait of Otranto, with the strongest events recorded on October 20, 1974 (Mw = 5.0), (CPTI11, Rovida et al., 2011) and May 7, 1983 (Ml = 5.3) (CSI 1.1, Castello et al., 2006).
The 1627, 1731, 1743 and 1889 earthquakes also generated considerable seismo-induced environmental effects such as tsunami deposits along the Apulian coasts, landslides, liquefaction phenomena and hydrological changes (Margottini, 1982; De Simone, 1993; De Martini et al., 2003; Mastronuzzi et al., 2007; Maramai et al., 2014).
The whole Apulia region has also been struck by strong earthquakes of neighbouring seismogenetic areas located in the Southern Apennines, Adriatic and Ionian Sea, Albania and Greece. Several ground effects, mostly hydrological variations, have been triggered in Northern Apulia by the July 23, 1930 Irpinia earthquake (Imax=X MCS) and the November 23, 1980 Irpinia-Basilicata earthquake (Imax=X MCS) (Porfido et al. 2002, Porfido et al. 2007).
The strongest historical seismic events of the Campania-Lucania Apennines that produced intensity values of I ≥ VI MCS in the Salento area, are the following:

- the 1456 Molise earthquake, Imax = XI MCS;
- the 1694 Irpinia-Basilicata earthquake, Imax=XI MCS;
- the 1857 Basilicata earthquake, Imax = XI MCS.

In addition, well documented examples of Greek earthquakes strongly felt in Salento and in the whole Apulia region were:

– the August 27, 1886 earthquake (epicenter in Peloponnesus, Greece) which was felt in the Salento area with very high values of intensity (I=VII MCS) (Margottini, 1982; Papazachos & Papazachou, 2003; Serva & Michetti, 2010; Grünthal et al., 2013);
– the May 28, 1897 earthquake (epicenter in Tripole, Greece) with intensity I=VI MCS in the Salento area (Margottini, 1982; Papazachos & Papazachou, 2003; Serva & Michetti, 2010, Grünthal et al., 2013);
– the August 11, 1903 earthquake (epicenter in Peloponnesus area) with I=IV-V MCS in the Salento area (Margottini 1982; Serva & Michetti, 2010);
– the June 26, 1926 earthquake (epicenter between Creta and Cipro, Imax=X MCS) which was severely felt all over the Southern Italy. The intensity in the town of Taranto (western Salento) was IV-V MCS (Castenetto et al., 1986);
– the August 28, 1962 earthquake (epicenter in Peloponnesus area) with I=IV-V MCS in the Salento area (Margottini 1982; Serva & Michetti, 2010).

The Salento peninsula was severely hit by the February 20, 1743 earthquake (I=IX MCS, M_w=7.1; CPTI11, Rovida et al., 2011), considered the strongest seismic event of the area, which also generated a large tsunami (Fig. 3) according to the Euro-Mediterranean Tsunami Catalogue (Maramai et al., 2014; NGDC/WDS, 2014). The 1743 epicenter is still very controversial due to the different locations ascribed respectively on land, near the town of Nardò (CFTIMED04, Guidoboni et al., 2007) and offshore, in the Ionian sea (CPTI11, Rovida et al., 2011). This earthquake caused mostly severe damage in Salento, killing about 180 people, 150 of which in the town of Nardò (Lecce), and inflicted heavy damage also in Francavilla Fontana (Brindisi) (Margottini, 1981, 1985). The seismic event was extensively felt on the

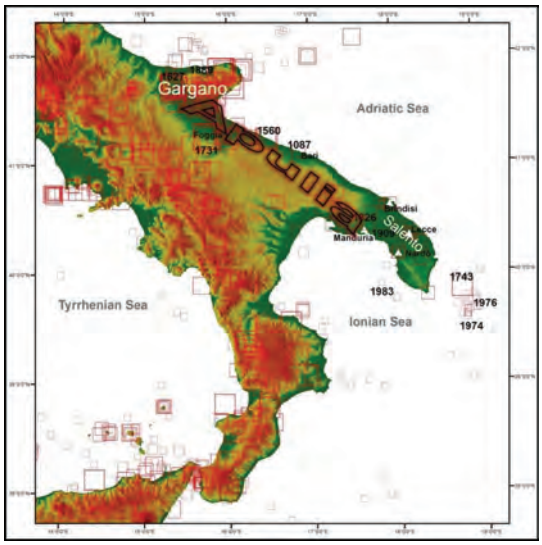

Figure 2: The map shows the spatial distribution of historical earthquakes occurred in the Apulian region, from Gargano to Salento, and in the Southern Italy extracted from CPTI11 (Rovida et al., 2011).

Figure 3: Boulders attributed to the 1743 seismo-induced tsunami on the Salento eastern coast (Torre S. Emiliano near Otranto (Lecce). (Photo by S. Porfido).

western coast of Greece, on the Malta island, in Southern Italy and in some localities of Central and Northern Italy.

DISCUSSION AND CONCLUSIONS

On the basis of recent scientific papers, (Margottini, 1981; Margottini, 1985; Ferrari, 1987; De Simone, 1993; Boschi et al., 1995; Galli & Naso, 2008, Nappi et al., 2014) and historical documents revision (De Giorgi, 1898; Baratta, 1901), a new estimation of the 1743 MCS intensity values of some localities, has been carried out. Furthermore, a critical review of archival documents coeval to the 1743 earthquake, found in the National Archives and church archives, has been performed. For obtaining a more accurate seismic hazard evaluation of the Salento area we have taken into account also geomorphologic data relative to environmental earthquake effects (Mastronuzzi et al., 2007; Nappi et al., 2014; De Lucia et al., 2014,) and architectural elements (De Lucia et al., 2013). The revision of the MCS intensity values and the assessment of the intensity according to the ESI scale, for some localities of the Salento area, have been performed on the basis of all the collected data and the seismoinduced environmental effects.

On the basis of the MCS scale, our re-evaluation has assigned the value of X MCS intensity to the town of Nardò, whose previous intensity value was IX MCS (Margottini, 1981, 1985; Boschi et al., 1995; Guidoboni et al., 2007) and the value of IX - X MCS (Galli & Naso, 2008); the value of IX MCS to Francavilla Fontana, VIII MCS to Castrignano del Capo, Leverano, Mesagne, Tuturano, Manduria, Racale, Salve, and VII MCS to the localities of Calimera, Copertino, Lecce, Oria, Ostuni, Seclì (Fig. 4).

For our re-evaluation of the 1743 earthquake on the basis of ESI scale, the tsunami phenomenon along the southern Adriatic coastline of Salento has been the most important environmental effect (Mastronuzzi et al., 2007; Mastronuzzi et al., 2011). Accordingly, for the town of Brindisi the ESI intensity value has been raised up from VIII to IX, due to the damage of the harbour mole caused by the tsunami.

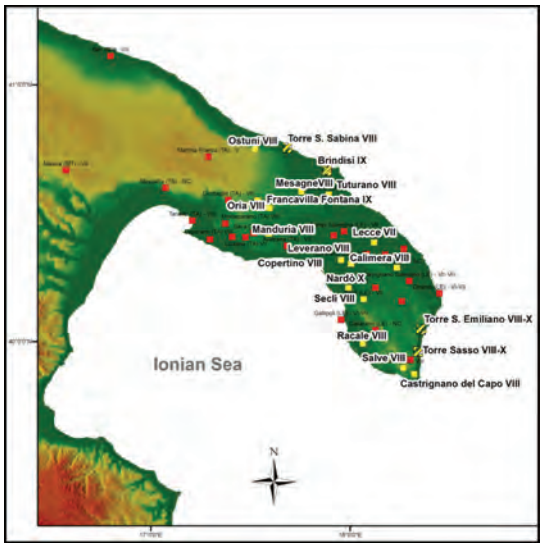

Figure 4: Map of the intensity values of the 1743 Salento earthquake: CFTIMED, 2007 MCS intensity values (red squares); re-evaluated MCS Intensity values in this study (yellow squares); re-evaluated ESI Intensity values in this study (yellow striped squares).

Moreover, it has been possible to assess the ESI intensity values of VIII≥ I ≥ X for the localities of Torre Sasso (Tricase) and Torre Sant' Emiliano (Otranto), along the coastline of the Salento peninsula, on the basis of the tsunami blocks dimensions consisting of large boulders with a maximum weight of about 70 tons (Mastronuzzi et al., 2007). Ground effect phenomena triggered by the 1743 earthquake also occurred in the town of Nardò where variations of the water flow rate of wells together with variations of chemical-physical properties of water were observed.

A wide area that includes Albania, Greece and Malta island (Ambraseys, 2009; Galea, 2007) suffered also significant ground seismo-induced effects. Indeed, in the northern area of the island of Kefalonia (Greece) changes of chemical-physical properties of water occurred, in Castel Sant'Angelo (Corfù, Greece) and Malta island landslides took place, and in Butrinto fortress (Albania) ruptures and probably liquefaction phenomena were observed.

In conclusion, a new macroseismic scenario for the 1743 earthquake has been hypothesized (Imax=X MCS), taking into account both the archival and geomorphological data. The earthquake triggered environmental effects that should be taken into account for the seismic intensity assessment, especially considering the destructive tsunami impact on the coastline of the Salento, currently crowded with tourists.

Consequently, the seismic hazard of the Salento peninsula must be re-evaluated and further study should be dedicated to this area, considering also a possible revision of the seismic classification.

Acknowledgements: We thank Prof. G. De Natale, Director of the Osservatorio Vesuviano, INGV (Napoli, Italy) that encouraged and supported this research; Prof. M.O. Spedicato and Prof. L. Ruggiero of the University of Salento; Prof. E. De Simone of the Liceo Scientifico Banzi Bazzoli of Lecce, for the useful discussion about the historical data of the Salento seismicity.

References

Ambraseys, N., (2009). *Earthquakes in the Mediterranean and Middle East.* Press. Cambridge University. 901 p.

Baratta, M., (1901). *I terremoti d'Italia.* Torino. 951 p.

Boschi, E., G. Ferrari, P. Gasperini, E. Guidoboni, G. Smriglio, G. Valensise, (1995*). Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980.* INGV-SGA. 974 p.

Caputo, M., G.F. Panza, D. Postpischl, (1970). Deep structure of the Mediterranean Basin. *Journal of Geophysical Research*, 75, 4919-4923.

Castello, B., G. Selvaggi, C. Chiarabba, A. Amato, (2006). *CSI Catalogo della sismicità italiana 1981-2002, versione 1.1.* INGV-CNT. Roma. http://csi.rm.ingv.it/.

Castenetto, S., E. Di Loreto, L. Liberi, C. Margottini, (1986). Studio macrosismico e risentimento in Italia dei terremoti del Mediterraneo centro-orientale del 26 giugno 1926 e del

17 gennaio 1983. In: *Atti del 4° Convegno del Gruppo Nazionale di Geofisica della Terra Solida*. 439-456.

Cinque, A., E. Patacca, P. Scandone, M. Tozzi, (1993). Quaternary kinematic evolution of the Southern Apennines. Relationship between surface geological features and deep lithospheric structures. *Annali di Geofisica*. 36 (2), 249-260.

De Giorgi, C., (1898). Ricerche su i terremoti avvenuti in Terra d'Otranto. *Mem. Pont. Acc. N. Lincei*. 15, 96-154.

De Lucia, M., R. Nappi, G. Gaudiosi, G. Alessio, (2013). *Sulle tracce del terremoto del 20 febbraio 1743 nei comuni danneggiati del Salento (Puglia meridionale).* Associazione Italiana di Geologia & Turismo. Atti del 5° Congresso Nazionale, 6-7 giugno 2013, Bologna. 141-142.

De Lucia, M., G. Alessio, G. Gaudiosi, R. Nappi, S. Porfido, (2014). A review of the Intensity values for the 1743 Salento earthquake. *Rendiconti Online Società Geololica Italiana*. Suppl. n.1, 31, 608 p. doi: 10.3301/ROL.2014.140.

De Martini, P.M., P. Burrato, D. Pantosti, A. Maramai, L. Graziani and H. Abramson, (2003). Identification of tsunami deposits and liquefaction features in the Gargano area (Italy): paleoseismological implications. *Annals of Geophysics*. 46, 883-902.

De Simone, E., (1993). *Vicende sismiche salentine*. Edizioni del Grifo. 152 p.

Ferrari, G., (1987). Some aspects of the seismological interpretation of information on historical earthquakes. In: *Proceeding, Workshop on historical seismicity*. (Margottini, C. and Serva, L., eds).

Galea, P., (2007). Seismic history of the Maltese islands and considerations on seismic risk. *Annals of Geophysics*. 50, 725-740.

Galli, P., G. Naso, (2008). The "taranta" effect of the 1743 earthquake in Salento (Apulia, Southern Italy). *Bollettino di Geofisica Teorica Applicata*. 49, (2), 177-204.

Gambini, R., M. Tozzi, (1996). Tertiary geodynamic evolution of the Southern Adria microplate. *Terra Nova*. 8, 593-602.

Grünthal, G., R. Wahlström, D. Stromeyer, (2013). The SHARE European Earthquake Catalogue (SHEEC) for the time period 1900-2006 and its comparison to the European Mediterranean Earthquake Catalogue (EMEC). *Journal of Seismology*. 17, (4), 1339-1344 doi: 10.1007/s10950-013-9379 y.

Guerrieri, L., E. Esposito, S. Porfido, A.M. Michetti, E. Vittori, (2012). La scala di intensità sismica ESI 2007 (Italian). *Memorie descrittive della carta geologica d'Italia*. 20-30 p. http://www.isprambiente.gov.it/files/progetti/inqua/esi-eee-volume-april-2012.pdf

Guidoboni, E., G. Ferrari, D. Mariotti, A. Comastri, G. Tarabusi, G. Valensise, (2007). CFTI4Med, Catalogue of Strong Earthquakes in Italy (461 B.C.-1997) and Mediterranean Area (760 B.C.-1500). Istituto Nazionale di Geofisica e Vulcanologia -SGA, Available from http://storing.ingv.it/cfti4med/

Maramai, A., B. Brizuela, L. Graziani, (2014). The Euro-Mediterranean Tsunami Catalogue. Annals of Geophysics, 57 (4) S0435; doi 10.4401/ag-6437.

Margottini, C., (1981). *Il terremoto del 1743 nella penisola salentina*. CNEL-ENEL, Congresso annuale del P.F.G. Udine. 12-14 maggio 1981.

Margottini, C., (1982). *Osservazioni su alcuni terremoti con epicentro in Oriente. Campo macrosismico in Italia del terremoto Greco del 1903*. CNEN-RT/AMB. 82 (3).

Margottini, C., (1985). The earthquake of february 20,1743, in the Ionian Sea. In: *Atlas of isoseismal maps of Italian earthquakes*. CNR-PFG. 114, 2A, 62 p.

Mastronuzzi, G., C. Pignatelli, P. Sansò, G. Selleri, (2007). Boulder accumulations produced by the 20th of February, 1743 tsunami along the coast of southeastern Salento (Apulia region, Italy). *Marine Geology*. 242, 191-205.

Mastronuzzi, G., R. Caputo, D. Di Bucci, U. Fracassi, V. Iurilli, M. Milella, C. Pignatelli, P. Sansò, G. Selleri, (2011). Middle-Late Pleistocene Evolution of the Adriatic Coastline of Southern Apulia (Italy). In: *Response to Relative Sea-Level Changes. Geografia Fisica e Dinamica del Quaternario*. 34, 207-221. doi: 1O.4461/GFDQ.2011.34.19.

Michetti, A.M., E. Esposito, L. Guerrieri, S. Porfido, L. Serva, R. Tatevossian, E. Vittori, F. Audemard, T. Azuma, J. Clague, V. Comerci, A. Gurpinar, J. Mc Calpin, B. Mohammadioun, N.A. Mörner, Y. Ota, E. Roghozin, (2007). Intensity Scale ESI 2007. *Memorie Descrittive della Carta Geologica d'Italia*. 74, 53 p.

Nappi, R., G. Gaudiosi, M. De Lucia, G. Alessio, S. Porfido, (2014). A critical revision of the Salento Peninsula seismicity: the case of the February 20, 1743 earthquake and related environmental effects. *Proceedings GNGTS,* Bologna, 25-27 Novembre 2014, (1) 101-107.

NGDC/WDS, National Geophysical Data Center / World Data Service (NGDC/WDS): Global Historical Tsunami Database. National Geophysical Data Center, NOAA. doi:10.7289/V5PN93H7 (2014 access date).

Papazachos, B.C., C. Papazachou, (2003). *The earthquakes of Greece*. Ziti publications. Thessaloniki. Greece. 286 p. (in Greek).

Porfido, S., E. Esposito, E. Vittori, G. Tranfaglia, A. M. Michetti, M. Blumetti, L. Ferreli, L. Guerrieri, L. Serva, (2002). Areal distribution of ground effects induced by strong earthquakes in the Southern Apennines (Italy). *Surveys in Geophysics*. 23 (6), 529-562.

Porfido, S., E. Esposito, E. Vittori, G. Tranfaglia, L. Guerrieri, R. Pece, (2007). Seismically induced ground effects of the 1805, 1930 and 1980 earthquakes in the Southern Apennines (Italy). *Bollettino della Società Geologica Italiana (Italian Jounal of Geoscience)*. 126, (2), 333-346.

Rovida, A., R. Camassi, P. Gasperini, M. Stucchi, (2011). *CPTI11, la versione 2011 del Catalogo Parametrico dei Terremoti Italiani*. Milano, Bologna, http://emidius.mi.ingv.it/CPTI. doi: 10.6092/INGV.IT-CPTI11.

Serva, L., A. M. Michetti, (2010). *Shakeistics: l'eredità degli studi nucleari in Italia per la valutazione del terremoto di riferimento per la progettazione degli impianti.* Insubria University Press. Fotoincisione Varesina. Varese. 48 p.

Stucchi, M., A. Rovida, A.A. Gomez Capera, P. Alexandre, T. Camelbeeck, M.B. Demircioglu, V. Kouskouna, P. Gasperini, R.M.W. Musson, M. Radulian, K. Sesetyan, S. Vilanova, D. Baumont, D. Fäh, W. Lenhardt, J.M. Martinez Solares, O. Scotti, M. Zivcic, P. Albini, J. Battlo, C. Papaioannou, R. Tatevossian, M. Locati, C. Meletti, D. Vigano, D. Giardini, (2013). The European Earthquake Catalogue (SHEEC) 1000-1899. *Journal of Seismology*. doi:10.1007/s10950-012-9335-2.

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