A CRITICAL REVISION OF THE SALENTO PENINSULA SEISMICITY: THE CASE OF THE FEBRUARY 20, 1743 EARTHQUAKE AND RELATED ENVIRONMENTAL EFFECTS.

R. Nappi[1], Alessio G., G. Gaudiosi[1], M. De Lucia[1], S. Porfido[2]

[1]. *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Napoli Osservatorio Vesuviano.*

[2]. *CNR-IAMC Napoli, Italy.*

Introduction. The area of the Salento peninsula (Apulia, Southern Italy) is considered the stable foreland of the Southern Apennines chain (Cinque et al., 1993), although it has been hit by several low energy and a few high energy earthquakes over the last centuries.

The aim of this study is a critical revision of the historical and recent seismicity of the Salento peninsula and surrounding seismogenetic areas, for re-evaluating the macroseismic effects in MCS scale and ground effects in natural environment, according to the ESI 2007 scale (Michetti et al., 2007; Guerrieri et al., 2012). In particular, the February 20, 1743 earthquake, the strongest of the area, was reviewed and new MCS intensity values were attributed to some localities. Moreover we have evaluated the most important effects on land in the Salento area due to the strong earthquakes of Northern Apulia, Southern Apennines, Adriatic and Ionian sea, Albania and Greece.

The use of both traditional MCS macroseismic intensity scale and the ESI 2007 scale gives a more accurate image of the earthquake (Dengler and McPherson, 1993; Porfido et al., 2007; Serva et al., 2007) and allowed us to better constrain the seismic hazard assessment in the Salento peninsula.

Geodynamic background. The central area of the Mediterranean basin is a plate-boundary region of high seismicity and complex tectonics, dominated by frequent earthquake activity occurring mostly in the Ionian Sea and Western Greece.

The Apulia region, NW-SE elongated, represents the emerged part of the Adriatic foreland domain shared by the Apennine chain to the west, and the Dinaride-Hellenide chain to the east (Moretti and Royden, 1988). The geodynamic background of this area is characterized by the ongoing subduction of the Ionian slab beneath the Calabrian Arc (Caputo et al., 1970), such compressional regime is still active and outlined by relevant seismicity (Castello et al., 2006).

As regards the tectonic setting of the Apennine-Dinaride converging region and surroundings, according to Gambini and Tozzi (1996) the major structural lineaments to be considered are: the Scutari-Pec Line; the Pescara-Dubrovnik dextral shear Line**;** the North Gargano Fault Zone; the Mattinata Gondola Fault Zone; the South Salento-North Kerkira Fault Zone; the right-lateral Cephalonia Transform Fault (see map in Gambini and Tozzi, 1996).

The rigid Apulian foreland block has been deformed through several normal faults, NW-SE and NNW-SSE trending, some of them presently active since they dislocate the sea floor by about 200–300 m (Merlini et al., 2000); moreover, major E-W strike-slip and oblique-slip fault zones divide Apulia into structural blocks behaving independently, among them the Gargano Promontory, the Murge Ridge and the Salento Peninsula are relevant.

In particular, the Salento peninsula represents the southernmost part of the Apulia foreland. The outcropping rocks are prevalently limestone-dolomite units belonging to the Apulia platform, with carbonatic-terrigenous marine deposits at the top of the stratigraphic sequence, Middle Eocene-Upper Pleistocene age (Mastronuzzi et al., 2011). The Salento peninsula has undergone a general uplift since Middle Pleistocene, with total amount of about 150 meters; after this period and in more recent times, neotectonic data indicate a significant stability of this area.

Seismicity of the area. Apulia is a region with relatively moderate seismicity surrounded by regions with destructive seismicity: 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) (Slejko et al., 1999).

The Northern part of the Apulia region is characterized by higher energy earthquakes than the Southern one. The strongest historical earthquakes of the last 1000 years occurred in the Apulian region from Gargano to Salento area were: July 30, 1627 (Gargano, Imax=X MCS); December 8, 1889 (Gargano, Imax=VII MCS); March 20, 1731 (Foggia, Imax=IX MCS); September 10, 1087, (Bari, Imax=VI-VII MCS); May 11, 1560 (Barletta-Bisceglie, Imax=VIII MCS); October 26, 1826 (Manduria, Imax=VI-VII MCS); January 20, 1909 (Nardò, Imax=VI MCS) and February 20, 1743, (Ionian sea, Imax=IX MCS) (CPTI11, Rovida et al., 2011; SHEEC, Stucchi et al. 2013, Grünthal et al., 2013). It is noticeable that the 1627, 1731, 1743 and 1889 earthquakes have also generated tsunami phenomena (Maramai et al., 2014) that caused damages along the Apulian coast.
Minor historical seismicity is distributed throughout the Salento area with intensity ranging from III to IV degree of the MCS macroseismic scale (CFTIMED04, Guidoboni et al., 2007).

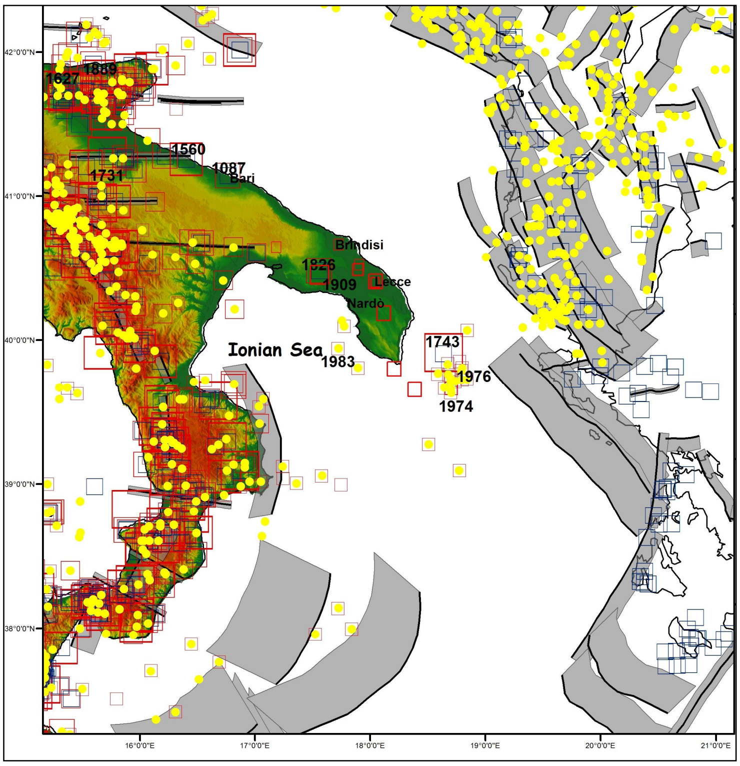

Fig. 1: The map shows the spatial distribution of historical and recent seismicity extracted from: CPTI11 (Rovida et al, 2011), red squares; SHEEC, (Stucchi et al., 2013) yellow dots, (Grünthal et al., 2013) blue squares. In grey the composite seismogenetic sources (Basili et al., 2013).

The instrumental recent seismicity in the Salento peninsula (Fig.2) is mainly concentrated in the western sector of the peninsula and in the strait of Otranto. The strongest recorded events occurred on October 20, 1974 (Mw= 5.0; CPTI11, Rovida et al., 2011) October 22, 1976 (Mw =4.9; CPTI11, Rovida et al., 2011) and May 7, 1983 (Ml =5.3; CSI 1.1, Castello et al., 2006) (Fig. 1).

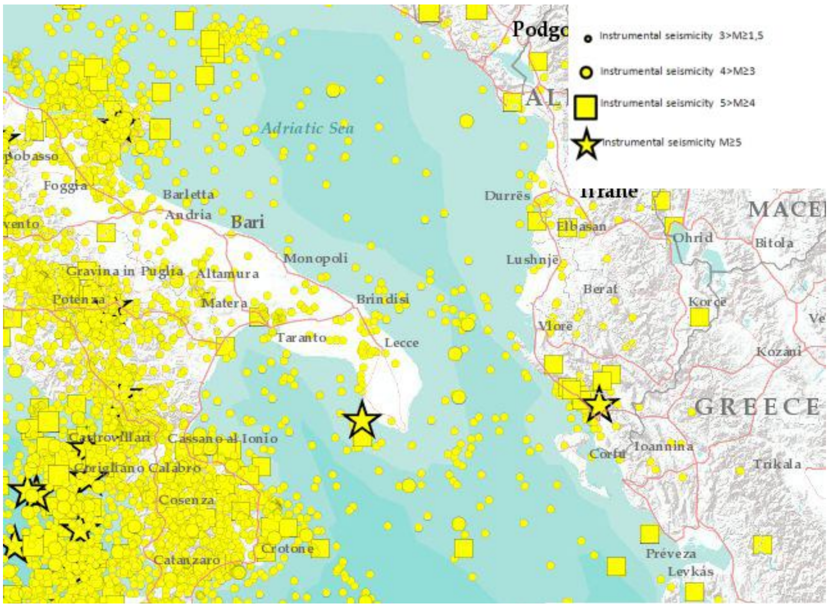

Fig. 2: Spatial distribution of 1981- 2014 seismicity (CSI, 1.1; http://bollettinosismico.rm.ingv.it/; http://iside.rm.ingv.it/iside/standard/index.jsp) extracted from LabGis, INGV.

Major earthquakes with epicentral zone in the far field

The Salento area suffers the strong earthquakes of neighboring seismogenetic areas as Northern Apulia, Southern Apennines, Adriatic and Ionian sea, Albania and Greece. The composite seismogenetic sources of the eastern Mediterranean area are shown in fig.1 (Basili et al., 2013).

It's well known that earthquakes with epicenter in the central-eastern Mediterranean (Greece, Ionian Islands) well propagate throughout the Italian peninsula, and in particular in the southern regions, where the intensity degrees are higher, sometimes exceeding the limit of damage.

Some well documented examples of Greek earthquakes (Serva e Michetti, 2010) are sintetically reported as follows:

- the August 27, 1886 earthquake (epicenter in Peloponnesus, Greece) (Margottini 1982) was felt in Salento area with very high values of intensity (I=VII MCS);
- the May 28, 1897 earthquake (epicenter in Creta - Cypro) reached I=VI MCS in Salento area;
- the August 28, 1962 earthquake (epicenter in Ionian Sea) was felt in Salento with I= VI MCS.
- the June 26, 1926 earthquake (epicenter between Creta and Cipro, Imax=X MCS) was well felt all over the Southern Italy. The intensity in the town of Taranto (western Salento) was IV- V MCS (Castanetto et al., 1985).

It is noteworthy that earthquakes located in the Southern Apennines were powerfully felt in the whole Apulia region; among the strongest historical events of the Campania-Lucania Apennines, the 1456 (Imax =XI MCS), 1694 (Imax =XI MCS) and 1857 (Imax =XI MCS) earthquakes caused effects of intensity I=VI MCS in some localities of Salento area. More recently, the July 23, 1930 (Imax =X MCS) and the November 23, 1980 (Imax =X MCS) Irpinia earthquakes gave rise to several ground effects, mostly hydrological variations, in the Apulian region. In details, I=VI-VII MCS was reached due to the 1930 seismic event while I=VI MSK was estimated for the 1980 earthquakes (Porfido et al 2002, Porfido et a 2007).

Environmental effects of the 1743 earthquake. The most severe damage in the Salento peninsula was caused by the Mw = 6.9, 1743 strong earthquake; the casualties were about 180, of which 150 in the town of Nardò. Heavy damage affected particularly the towns of Nardò (Lecce) and Francavilla Fontana (Brindisi) (Margottini, 1981, 1985). The seismic event was also felt on the western coast of Greece, on the Malta island, in Southern Italy and in some localities of Central and

Northern Italy. The 1743 earthquake also generated a tsunami, which deposits are distributed along the southern Adriatic coastline of Salento (Mastronuzzi et al., 2007; Galli and Naso, 2008).
This earthquake is described in a large amount of historical documents and seismic catalogues, however the location and geometry of the seismogenetic source is still a subject of scientific debate.
In this paper a revaluation of the 1743 MCS intensity for the damaged localities, on the basis of recent scientific literature, (Margottini, 1981; Margottini, 1985; Ferrari, 1987; De Simone, 1993; Boschi et al., 1995; Galli and Naso, 2008) has been carried out. The most damaged town was Nardò, where X MCS intensity value was assigned. Accordingly, it was possible to attribute values of IX MCS to the town of Francavilla Fontana, VIII MCS to the towns of Brindisi, Castrignano del Capo, Leverano, Mesagne, Tuturano, Manduria, Racale, Salve, and VII MCS to Calimera, Copertino, Lecce, Oria, Ostuni, Seclì.
Furthermore, a critical review of historical sources, especially archival documents coeval to the 1743 earthquake, found in different National Archives in Italy and in local church archives, has been performed. For a more complete evaluation of the earthquake from a macroseismic point of view, it is of fundamental importance to take into account both the direct information derived from archival and historiographic sources and also the indirect geomorphologic data referable to environmental earthquake effects.
The environmental effects triggered by the 1743 seismic event, mostly consisting in secondary effects, have been also documented by coeval reports:

- in the town of Brindisi a tsunami was described, with fractures in the sea floor: *"…. è stato così spaventoso, che ritirandosi il mare, faceansi vedere aperture della terra, et il molo di porta Reale diviso in tre parti…"* (Ascoli F., in De Simone, 1993).
- in the neighbouring of the Butrinto fortress (Albania) ruptures and probably liquefaction phenomena in the ground were observed: *"….the ground opened, and it was rising up, and water and smoke come through the cracks..."* (ASV b.988, in Ambraseys, 2009)
- in the town of Nardò variations of the water flow-rate of wells were observed, together with variations of chemical-physical properties of water: *"nel giorno di Mercoledì venti febbraio 1743…l'acque ne' pozzi saltavano, e si riconcentravano…"* (ASL 1743, Protocolli Notarili);
- in the northern area of the island of Kefalonia (Greece) changes of chemical-physical properties of water were observed: "*The island of Cephalonia… in the 1736, 1743 and 1752… particularly in the northern part if island. It has been observed that strong odours of sulphur come up from wells*" (Saint Sauver, 1794, iii. 36, in Ambraseys, 2009);
- in the locality of Castel Sant'Angelo (Corfù, Greece) the earthquake triggered a rockfall;
- in the locality of Torre Sant'Emiliano tsunami deposits consisting of large boulders were observed, along the coastline, with a maximum weight of about 70 t and a run up of about 11 m (Mastronuzzi et al., 2007);
- in the locality of Torre Sasso tsunami deposits consisting of large boulders were observed, along the coastline, with a maximum weight of about 31 t and a run up of about 5 m (Mastronuzzi et al., 2007).

Mainly for the last two localities strucked by the 1743 event, Torre Sant'Emiliano e Torre Sasso, well documented geomorphologic evidences of tsunami deposits (Mastronuzzi et al., 2004, 2007) have been essential and firstly considered in order to assess the intensity values.
All the collected data on the induced environmental effects have allowed us to review the MCS intensity values for some localities; as regards the town of Brindisi the intensity value has been further raised up from VIII to IX, due to the damage level and moreover to the tsunami phenomenon occurrence (Fig. 3).
Intensity values of I ≥ VIII according to the ESI 2007 scale have been assessed for the localities of Torre Sasso (Tricase) and Torre Sant' Emiliano (Otranto), along the coastline of the Salento

peninsula, as proved by the tsunami blocks dimensions; however, further constraining evidences have still to be uncovered.

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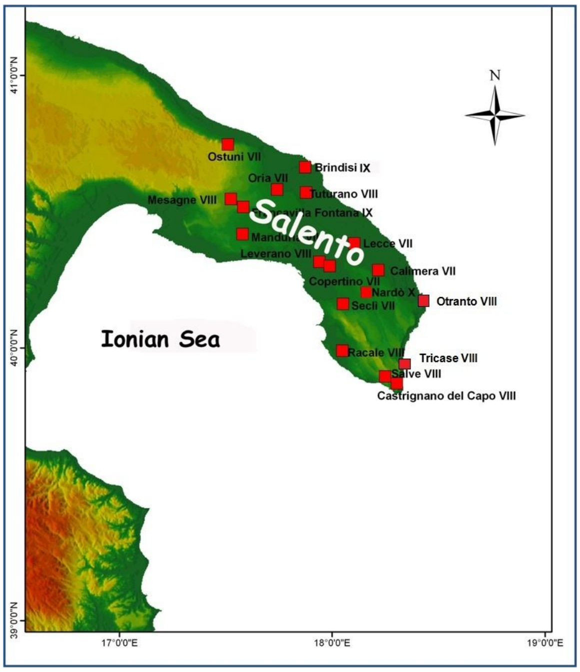

Fig.3: Map of the new intensity values revaluated in this paper for the 1743 Salento earthquake

Preliminary results. The critical analysis of the documentary and historical sources, besides the geomorphologic evidences of effects due to the strong 1743 Salento earthquake, have allowed us to remodel a quite different scenario for this earthquake, leading to differently assessed intensity values for some localities, and also to new original estimations of intensity values for others.

Actually, strong earthquakes occurred in the far field respect to the Salento area, like the significant seismic events that have repeatedly hit Greece and Albania in the last centuries, have also caused heavy damages and serious tsunami effects in the Apulia region and Salento peninsula, despite the apparently low energy seismicity characterizing these areas, in comparison with other seismic areas of Italy.

Consequently and according to our research, the seismic potential of the Salento peninsula could be better evaluated and further study should be dedicated to this subject, as well as the current classification of this region in IV category (Seismic Classification Map of the Italian territory; MPSO4 – Order PCM 3519/2006) should be also revised.

References

Ambraseys N.; 2009. *Earthquakes in the Mediterranean and Middle East.* Cambridge University Press, pp.901.

ASL (Archivio di Stato di Lecce) sezione notarile, protocollo 66/17 notaio Oronzo Ipazio De Carlo anno 1743 cc. 204 r/v,205 r.

Basili R., Kastelic V., Demircioglu M. B., Garcia Moreno D., Nemser E. S., Petricca P., Sboras S. P., Besana-Ostman G. M., Cabral J., Camelbeeck T., Caputo R., Danciu L., Domac H., Fonseca J., García-Mayordomo J., Giardini D., Glavatovic B., Gulen L., Ince Y., Pavlides S., Sesetyan K., Tarabusi G., Tiberti M. M., Utkucu M., Valensise G., Vanneste K., Vilanova S., Wössner J.; 2013: *The European Database of Seismogenic Faults (EDSF)* compiled in the framework of the Project SHARE. http://diss.rm.ingv.it/share-edsf/, doi: 10.6092/INGV.IT-SHARE-EDSF.

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

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

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

Castenetto S., Di Loreto E., Liberi L., Margottini C.; 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, pp. 439-456.

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

Dengler, L., McPherson, R.;1993: *The 17 August 1991 Honeydaw earthquake, north coast California: a case for revising the Modified Mercalli Scale in sparsely populated areas*. Bulletin of the Seismological Society of America 83, 1081–1094.

De Simone E.; 1993: *Vicende sismiche salentine*. Edizioni del Grifo pp.152

Ferrari G.; 1987: *Some aspects of the seismological interpretation of information on historical earthquakes*. Proc.Workshop on historical seismicity (Margottini and Serva eds).

Galli P., Naso G.; 2008: *The "taranta" effect of the 1743 earthquake in Salento (Apulia, Southern Italy)*. BGTA. Vol. 49, n. 2, pp. 177-204.

Gambini R., Tozzi M.; 1996: *Tertiary geodynamic evolution of the Southern Adria microplate*. TerraNova, 8, 593-602.

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

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

Maramai A., Brizuela B., Graziani L.; 2014: *The Euro-Mediterranean Tsunami Catalogue*. Annals of Geophysics, 57, 4, 2014, 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 earthquqke of february 20,1743, in the Ionian Sea. In Atlas of isoseismal maps of Italian earthquqke*. CNR-PFG n.114, vol. 2A, p. 62.

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

Mastronuzzi G., Caputo R., Di Bucci D., Fracassi U., Iurilli V., Milella M., Pignatelli C., Sanso' P., Selleri G.; 2011: *Middle-Late Pleistocene Evolution of the Adriatic Coastline of Southern Apulia (Italy)* in : Response to Relative Sea-Level Changes. Geogr. Fis. Dinam. Quat. DOl 1O.4461/GFDQ.2011.34.19 34 (2011), 207-221, 13 figg., 2 tabb.

Merlini S., Cantarella G., Doglioni C.; 2000: *On the seismic profile Crop M5 in the Ionian Sea*. Boll. Soc. Geol. Ital. 119, 227–236.

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

Moretti I. and Royden L.;1988: *Deflection, gravity anomalies and tectonics of doubly subducted continental lithosphere: Adriatic and lonian Sea.* Tectonics, 4, 675-693.

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

Porfido S. Esposito E., Vittori E., Tranfaglia G., Guerrieri L. Pece, R; 2007: *Seismically induced ground effects of the 1805, 1930 and 1980 earthquakes in the Southern Apennines (Italy)*. Boll.Soc.Geol.It. (Ital .J. Geosci.), 126, 2 , pp. 333-346.

Rovida A., Camassi R., Gasperini P., Stucchi M.; 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., Esposito E., Guerrieri L., Porfido S., Vittori E., Comerci V.; 2007: *Environmental effects from five hystorical earthquakes in Southern Apennines (Italy) and macroseismic intensity assessment*. Contribution to INQUA EEE Scale Project. Quaternary Int., 173-174, 30-44.

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

Slejko D., Camassi R., Cecic I., Herak D., Herak M., Kociu S., Kouskouna V., Lapajne J.,Makropoulos K.,Meletti C., Muco B., Papaioannou C., Peruzza L., Rebez A., Scandone P., Sulstarova E., Voulgaris N., Zivcic M., Zupancic P.; 1999: *Seismic hazard assessment for Adria*. Ann. Geofis. 42, 1085–1107.

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