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THE LITTLE-KNOWN EARTHQUAKE OF 1643 IN SICILY

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ABSTRACT: With earthquakes being most common to eastern Sicily (Mw >7.0), the mountainous region northwest of Mount Etna (Madonie-Nebrodi range) is affected by sparse, low magnitude seismicity (Mw ≤5.0), with macroseismic intensities ≤7-8 MCS. Among these, the 1643 event is currently rated with an intensity of 6-7 MCS degree, related to only one locality (Troina, Enna province). New information retrieved from a coeval manuscript discovered in the National Library of Spain in Madrid, together with other unknown documents, allows now to provide a reliable damaging scenario for the mesoseismic area of the 1643 sequence. News concern five localities, accounting for an epicentral intensity of 8 MCS and a related Mw 5.6, which is the strongest of the region. In some villages, the 1643 effects were even higher than in 1693, the catastrophic earthquake that razed to the ground dozen of towns in eastern Sicily, with damage from Malta to Palermo. The E-W elongated damage area fully matches the normal-fault plane solution of the focal mechanisms of two recent earthquakes falling close to the 1643 epicenter, suggesting thus a similar trend for the seismogenic structure. The earthquake was also followed by an unreported activity of Mount Etna which was dormant since 1638.

Keywords: historical seismology, 1643 earthquake, Nebrodi seismicity, Etna eruptions

1. INTRODUCTION

The seismicity of Sicily is mainly clustered in the easternmost side of the island. Leaving aside the isolated 1968 Belice sequence in western Sicily (Mw 6.3), or the offshore seismicity paralleling the entire northern Tyrrenian coast, from Ustica to the Aeolian Islands (e.g., events of 2002, Mw 5.9; 1823, Mw 6.5; 1978, Mw 6.1), all the strongest historical earthquakes occurred between the Hyblean Plateau to the south, and the Messina Strait to the north (Fig. 1). Among these, there are the most catastrophic events ever happened in Europe, as those in January 9 and 11, 1693 (Mw ~6 and Mw 7.3, respectively), with a possible ancestor in February 4, 1169 (Mw ~6.5), and the December 28, 1908 earthquake and tsunamis (Mw 7.3). Furthermore, Mw>6 events occurred in 1542 (Lentini area: Mw 6.4), 1818 (southern Etna area: Mw 6.2), and 1786 (Patti area: Mw 6.2), besides sever others spanning 5.5<Mw<6.0, with epicenters mainly in the Hyblean Plateau and along its eastern coast.

Conversely, in the rest of Sicily, and chiefly northwest to Mount Etna (i.e., E-W trending ranges of Nebrodi-Madonie Mountains; Fig. 1), the seismic catalogues report sparse epicenters of low magnitude earthquakes (Mw ≤ 5.5), which are seldom responsible for damage, as in the 1818 and 1819 events (Io 7-8 MCS; Madonie Mountains) or in the 1967 earthquake (Io 8 MCS; Nebrodi Mountains). According to the seismic compilations (e.g., Mongitore, 1743; Mercalli, 1883; Baratta, 1901; Postpischl, 1985; CPTI, 2011: from now CPTI11), in 1643 another event hit the town of Troina (Nebrodi Mountains), with effects rated at the 6-7 MCS degree.

Here I present new detailed information on this earthquake extracted from different contemporary documents which have remained hidden in the archives during the past 350 years. The news contained in these manuscripts allow to define the damage extent in Troina and in other neighboring villages, contemporary also to an unknown eruptive activity of the Etna Volcano.

2. THE 1643 SEISMIC SEQUENCE

As aforementioned, this earthquake is reported by Baratta (1901) to be occurred in Troina on July 17 when, due to a violent shock, all the inhabitants left their houses, and part of the mother-church and the monastery of Saint Elias of Ambola (Ambula, Ambolà, Ebulo/i) collapsed. The only source of Baratta (1901) is Mongitore (1743) who, in turn, deduces the news from Pirri (1647). Basing on this information, Barbano et al. (1996) assign 6-7 MCS to Troina, as reported today in CPTI11 (Fig. 2).

As serendipity is a usual phenomenon in historical seismology, while I was looking for information on other earthquakes, I have found unknown news of this event examining some journalistic *Avisos* printed in Madrid (in Valladares de Sotomayor, 1790). Firstly, the one dated October 13, 1643 which reports a vague notice about the explosion of the Etna, and of the resulting destruction caused in Sicily. Then, the following (October 20) indicating with much more detail what really happened since July 17 in the "*Ciudad y Comarca de Traina, la mas populosa del Val de Moac*" (i.e., Val Demone. Troina exceeded 5,500 inhabitants in the 17th century; Maggiore-Perni, 1892), as in Cherame (Cerami), Nicosia and Bronte (Fig. 3).

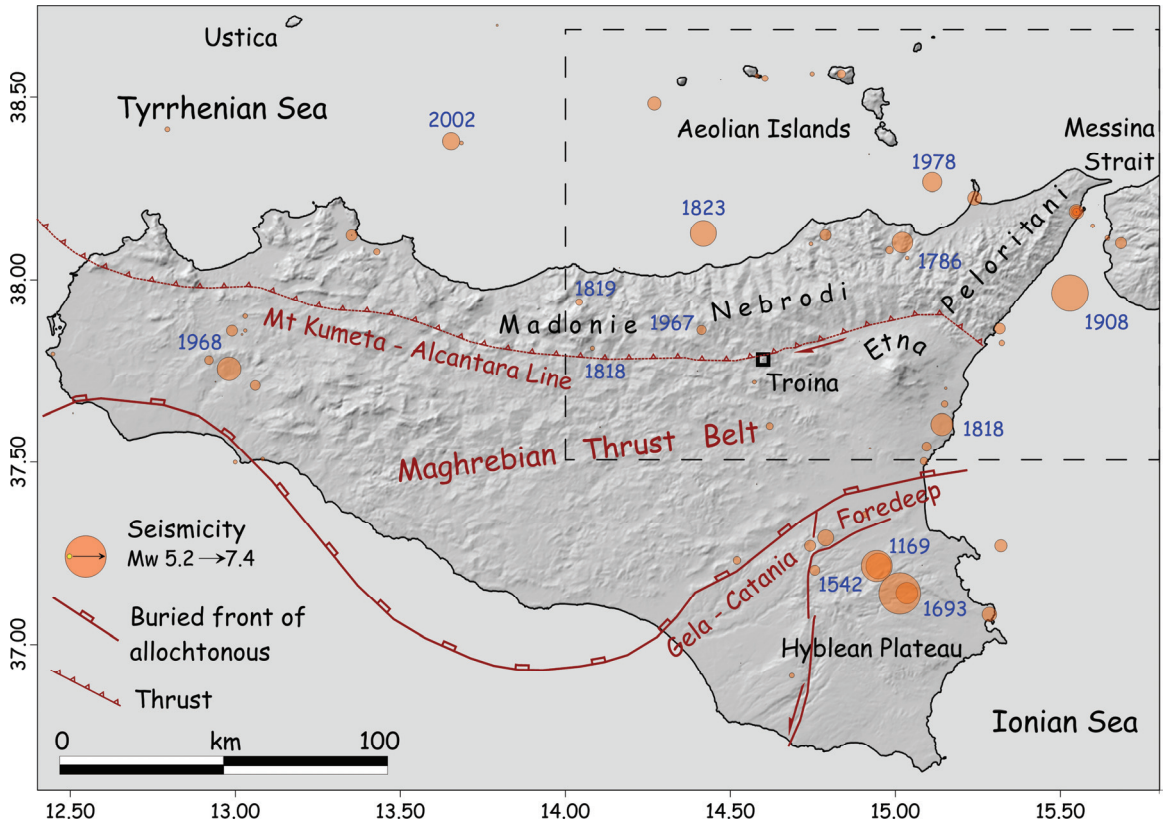


Fig. 1 - Distribution of the macroseismic epicenters of 4.9≤Mw≤7.3 earthquakes listed in the CPTI11 (N.B., the 1908 epicenter is an instrumental estimate proposed by Michelini et al., 2004). Note that the strongest events are all clustered in eastern Sicily, between the Hyblean Plateau and the Messina Strait. In turn, Madonie and Nebrodi mountains have only scattered Mw≤5.5 earthquakes. Dashed rectangle, area of Fig. 9.

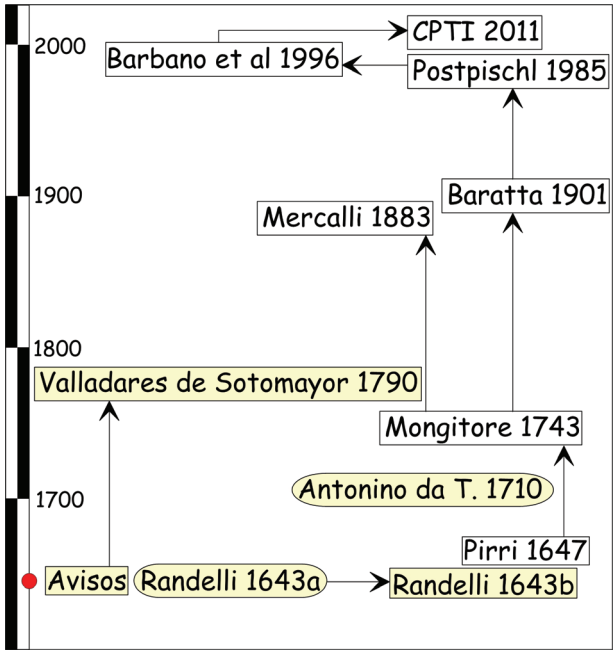
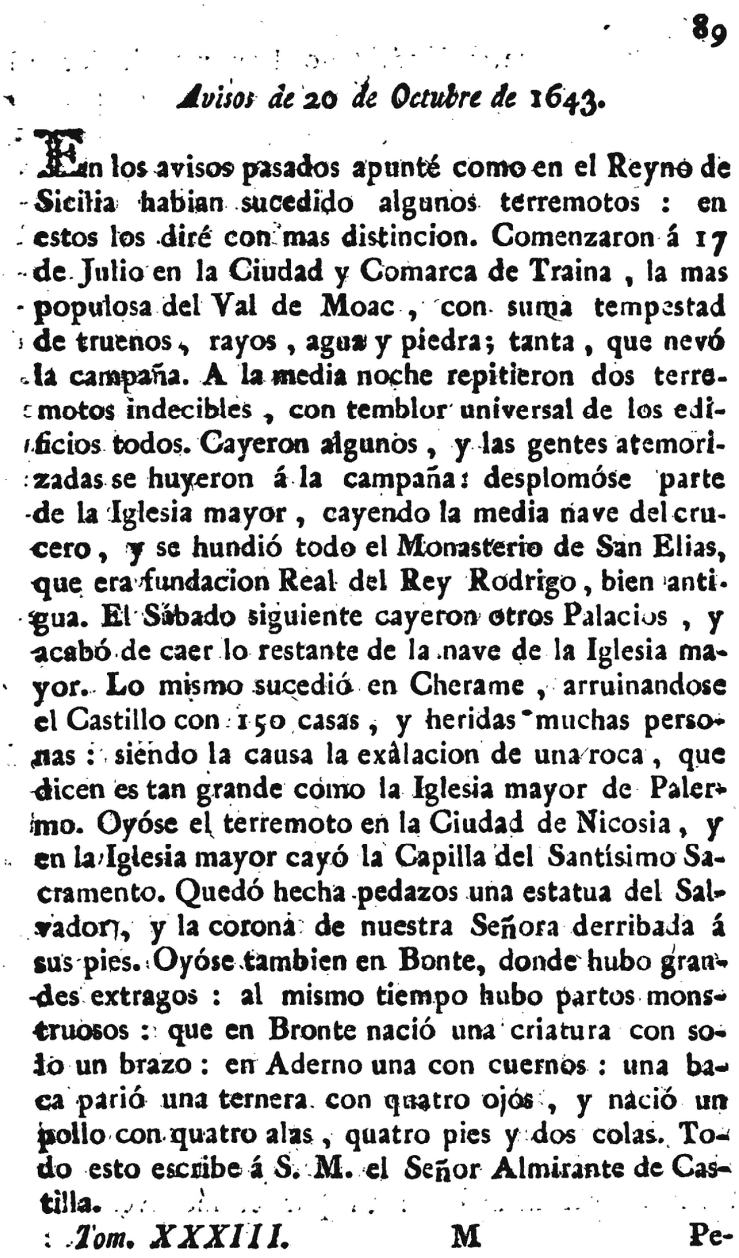


Fig. 2 - Family tree of sources for the 1643 earthquake. Rectange, printed studies; rounded rectangle, manuscripts; yellow indicates the unknown sources discussed in this paper. Note that the only real source of CPTI11 is Pirri (1647).



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Avisos de 20 de Octubre de 1643.

En los avisos pasados apunté como en el Reyno de Sicilia habian sucedido algunos terremotos : en estos los diré con mas distincion. Comenzaron á 17 de Julio en la Ciudad y Comarca de Traina , la mas populosa del Val de Moac , con suma tempestad de truenos , rayos , agua y piedra; tanta , que nevó la campaña. A la media noche repitieron dos terremotos indecibles , con temblor universal de los edificios todos. Cayeron algunos , y las gentes atemorizadas se huyeron á la campaña: desplomóse parte de la Iglesia mayor , cayendo la media nave del crucero , y se hundió todo el Monasterio de San Elias, que era fundacion Real del Rey Rodrigo , bien antigua. El Sábado siguiente cayeron otros Palacios , y acabó de caer lo restante de la nave de la Iglesia mayor. Lo mismo sucedió en Cherame , arruinandose el Castillo con 150 casas , y heridas muchas personas : siendo la causa la exâlacion de una roca , que dicen es tan grande como la Iglesia mayor de Palermo. Oyóse el terremoto en la Ciudad de Nicosia , y en la Iglesia mayor cayó la Capilla del Santísimo Sacramento. Quedó hecha pedazos una estatua del Salvador, y la corona de nuestra Señora derribada á sus pies. Oyóse tambien en Bonte, donde hubo grandes extragos : al mismo tiempo hubo partos monstruosos : que en Bronte nació una criatura con solo un brazo : en Aderno una con cuernos : una baca parió una ternera con quatro ojos , y nació un pollo con quatro alas , quatro pies y dos colas. Todo esto escribe á S. M. el Señor Almirante de Castilla.

Fig. 3 - Copy of the first page of the Avisos printed in Madrid with the first news on the 1643 earthquake in Sicily (from Valladares de Sotomayor, 1790)

Clearly, these *Avisos* were based on a more detailed report that I have finally found in the Biblioteca National de España (Madrid). This is a eight page-long manuscript - included in a volume of *Papeles varios* - which contains the report of Silvestro Randelli on the earthquakes *en la ciudad de Trayna* and on the effects caused there and in the surrounding region (Fig. 4). Randelli (*Sylvestro Randeli* in the manuscript) was the fiscal Prosecutor of the Tribunal of the Great Court, and was also a notary in Troina, a title which implies that he was an expert of all the places, of the real estate and of their condition. His report was printed later in Madrid by Diego Diaz (*Relacion de los terremotos....por el Dotor Silvestre Randole*), although with some differences with respect to the original manuscript (Fig. 5; Randelli, 1643b).

According to Randelli (1643a), the seismic sequence started in August 1642, with two strong shocks in the night of 21 (around 0:30 a.m., local time) and 22 (around 2:45 a.m.). These events scared all the inhabitants of Troina that sought refuge in the countryside, where they observed several sulphur-smell fissures

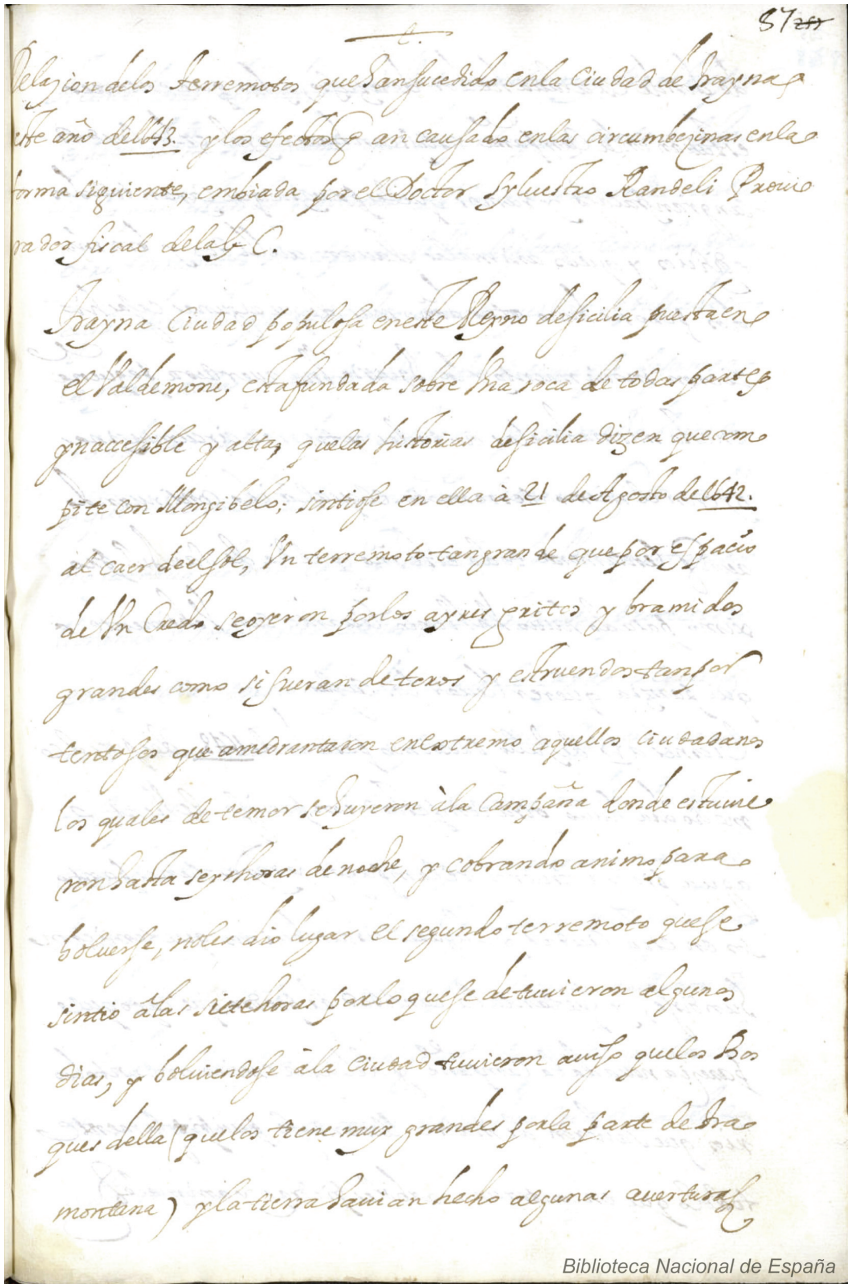
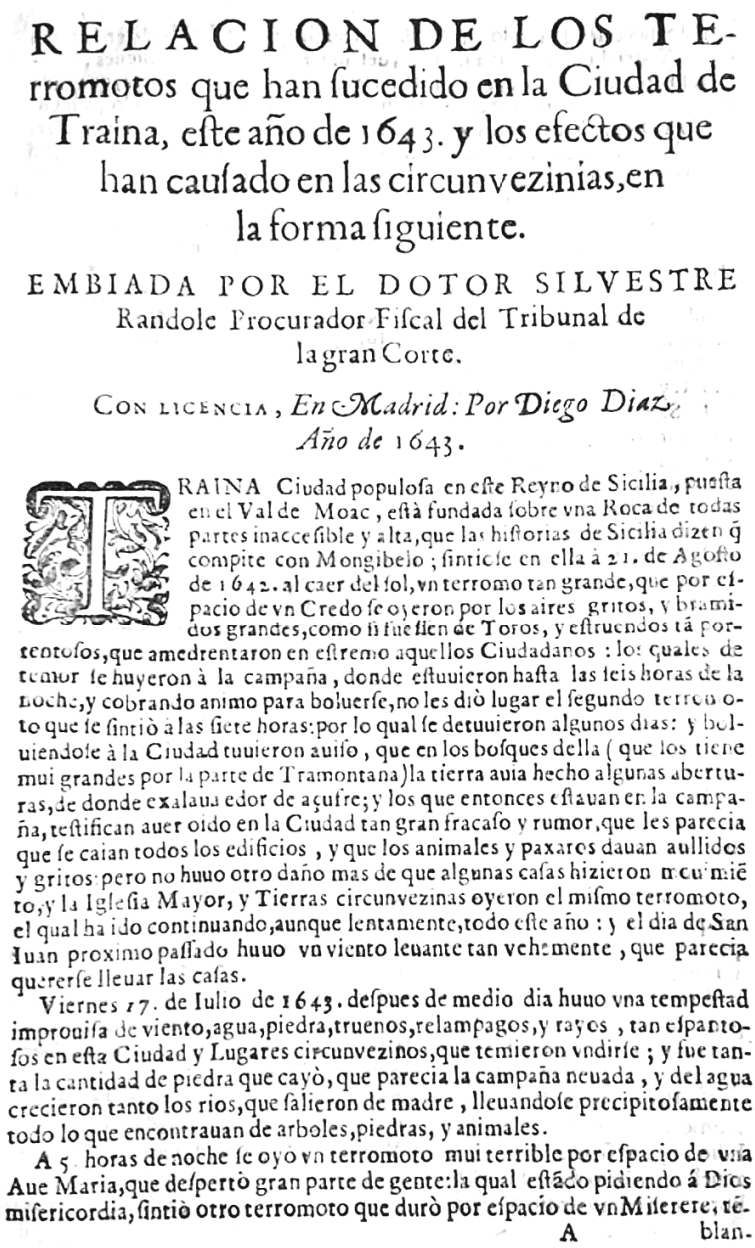


Fig. 4 - First page of the report by Silvestro Randelli on the effects of the 1643 earthquakes in Troina, Cerami, Bronte, Nicosia and on the contemporary Etna eruption (Manuscript 11209 of the Biblioteca Nacional de España). At the top of the page it can be read: *Relacion de los terremotos que han sucedido en la ciudad de Trayna este año de 1643 y los efectos que an causado en las circumbecinas en la forma siguiente, embiada por el Doctor Sylvestro Randeli Procurador fiscal de la G[ran] C[orte]*

opening in the ground surface. Damage to buildings was generally light, except in the mother-church, where a deep crack opened in the wall. Earthquakes were felt again in June 21 of the next year, and then again in July 12 and 15, especially in Bronte.

The 1643 mainshock occurred at 1:20 a.m. of July 18 (the 5th hour of the night of Friday 17; i.e., five hours after the sunset, accordingly to Italian time), lasting for the time of an *Ave Maria* (around 10''), and then replying suddenly for a much longer time (i.e., a *Miserere*, more than 1'). In Troina, the people escaped from the houses without clothes, screaming and invoking God and all the Saints. The earthquake damaged all the buildings, some more and other less, whereas five houses collapsed, causing two casualties and injuring several persons. Also part of the nave of the mother-church fell down (it collapsed entirely on Sunday, due to an aftershock), as the church of Saint Sylvester and the Monastery of Saint Elias of Ambulà (located far away from the town), as reported also in another manuscript composed by An-



RELACION DE LOS TE-
rromotos que han ſucedido en la Ciudad de
Traina, eſte año de 1643. y los efectos que
han cauſado en las circunvezinias, en
la forma ſiguiente.

EMBIADA POR EL DOTOR SILVESTRE
Randole Procurador Fiſcal del Tribunal de
la gran Corte.

CON LICENCIA, *En Madrid: Por Diego Diaz,*
Año de 1643.

TRAINA Ciudad populoſa en eſte Reyno de Sicilia, puеſta en el Val de Moac, eſtà fundada ſobre vna Roca de todas partes inacceſsible y alta, que las hiſtorias de Sicilia dizen q̃ compite con Mongibelo; ſintioſe en ella à 21. de Agoſto de 1642. al caer del ſol, vn terromo tan grande, que por eſpacio de vn Credo ſe oyeron por los aires gritos, y bramidos grandes, como ſi fueſſen de Toros, y eſtruendos tã portentoſos, que amedrentaron en eſtremo aquellos Ciudadanos: los quales de temor ſe huyeron à la campaña, donde eſtuuieron haſta las ſeis horas de la noche, y cobrando animo para boluerſe, no les diò lugar el ſegundo terremoto que ſe ſintiò à las ſiete horas: por lo qual ſe detuuieron algunos dias: y boluiendoſe à la Ciudad tuuieron auiſo, que en los boſques della (que los tiene mui grandes por la parte de Tramontana) la tierra auia hecho algunas aberturas, de donde exalaua edor de açufre; y los que entonces eſtauan en la campaña, teſtifican auer oido en la Ciudad tan gran fracaſo y rumor, que les parecia que ſe caian todos los edificios, y que los animales y paxaros dauan aullidos y gritos: pero no huuo otro daño mas de que algunas caſas hizieron mouimiẽto, y la Igleſia Mayor, y Tierras circunvezinas oyeron el miſmo terromoto, el qual ha ido continuando, aunque lentamente, todo eſte año: y el dia de San Iuan proximo paſſado huuo vn viento leuante tan vehemente, que parecia quererſe lleuar las caſas.

Viernes 17. de Iulio de 1643. deſpues de medio dia huuo vna tempeſtad improuiſa de viento, agua, piedra, truenos, relampagos, y rayos, tan eſpantoſos en eſta Ciudad y Lugares circunvezinos, que temieron vndirſe; y fue tanta la cantidad de piedra que cayò, que parecia la campaña neuada, y del agua crecieron tanto los rios, que ſalieron de madre, lleuandoſe precipitoſamente todo lo que encontrauan de arboles, piedras, y animales.

A 5 horas de noche ſe oyò vn terromoto mui terrible por eſpacio de vna Aue Maria, que deſpertò gran parte de gente: la qual eſtãdo pidiendo á Dios miſericordia, ſintiò otro terromoto que durò por eſpacio de vn Miſerere, tẽ-

A blan-

Fig. 5 - Copy of the first page of the *Relacion* of Silvestro Randelli (1643b; here *Silvestre Randole*) printed in Madrid by Diego Diaz. The printed version slightly differs from the manuscript.

tonino da Troina (1710), a friar born and lived in Troina (see also Pirri, 1647).

In Cerami the effects were much stronger, as the castle was destroyed, and the churches in the highest part of the village collapsed (likely the mother-church and Saint Sebastian). Also 150 houses were destroyed, plus other 50 in the countryside, causing one casualty and 30 injured. A huge rocky mass, which Randelli (1643a) describes big as the Palermo cathedral (i.e., ~80,000 m^3), detached from the sandstone cliff over which Cerami is founded, destroying everything downhill, including trees and vineyards. The landslide left some houses in very unsafe equilibrium, i.e., some downthrown from their original position, other rotated.

In Bronte all buildings were damaged, three person died and three were injured under the collapse of their house. Churches also were severely hit, with restorations made in the same year (e.g. in Fig. 6).

In Nicosia the earthquake was less violent, causing only the partial collapse of the Chapel of the Blessed Sacrament in the mother-church, together with the fall of several statues inside (see Fig. 7 to see all the localities

Fig. 6 - Inscription over the architrave of San Vito church in Bronte, attesting the restoration made in 1643 by Matteo and Michele di Palermo, under the priorate of Antonio da Bronte. Although the earthquake is not explicitly recalled here (as elsewhere in any other epigraph in the region), it is likely that the restoration work concerned also the earthquake damage.

that were struck by the earthquake in a 17th century map).

Randelli (1643a) highlights also that from July 18 to 28, the mainshock was accompanied by a noticeable activity of Mount Etna, that incessantly generated roars resembling heavy artillery shells. During the seismic sequence, Etna erupted from a mouth which opened in front of the major one. Huge ground deformation phenomena were also observed on the volcano slopes, as the progressive lowering of a hill with 3-miles of perimeter. A secondary mouth opened also in the territory of Bronte, where it happened that all the streams feeding the numerous mills at the Etna's foothill dried up. According to Randelli (1643a), this "*es señal de no haver cessado la causa de el temblor de la tierra*" (i.e., this fact is a clear signal that the cause of the earthquakes are not yet ceased). It is worth noting that this activity of the volcano, that had remained silent since the long eruption in 1634-1638 (e.g. in Guidoboni et al., 2014), is completely unknown to the historical/scientific literature.

The aftershocks sequence was still ongoing in August, when at dawn of 12 a strong earthquake struck again the region.

Curiously, at the end of the Randelli's manuscript, the author notes several women with miscarriages, and animal freaks being born in the aftermath (e.g., a calf with four eyes, a chicken with four wings, four feet and two tails).

3. DISCUSSION

3.1. Earthquake parameters

On the basis of the description provided by Randelli (1643a), it is likely that the most severe effects were felt in the village of Cerami where, alongside the ruin of the castle and of some churches, 200 houses were destroyed or, at least, strongly damaged, whereas all were severely hit. Here, the strong seismic shaking is also suggested by the huge rock fall that affected the upper part of the town, the signs of which can still be imaged today by observing its suggestive skyline (Fig. 8).

This allow to assign at least 8-9 MCS degree in Cerami, something more than in Troina (8 MCS) where

Fig. 7 - Clip from a map of Funk and Homann (ca. 1700; base-topography redraw from G. Mercator, 1512-1594) with the localities hit by the January 1693 earthquakes (asterisks indicate *loca terremotu destructa*; i.e., places destroyed by the earthquake). In turn, yellow lines evidence the localities struck by the 1643 event: Troina (*Traina* in the map), Bronte (*Bronti*), Cerami (*Cirami*), Nicosia, and the Monastery of Saint Elias of Ambulà (*Eubuli*). *Aetna Mons Mongibello* is, obviously, Mount Etna.

all the buildings were damaged too, and few collapsed (Fig. 9). Also in Bronte all buildings were damaged, whereas some collapsed; however, here the information does not allow to give a certain site intensity degree, and thus I suggest 7-8 MCS. In Nicosia, where Randelli (1643a) indicates heavy damage only in the mother-church, intensity could be estimated around 6-7 MCS. At the end, there is another locality 8 km north of Troina (Figs. 7, 9), the disruption of which is maintained by Randelli (1643a), Antonino da Troina (1710), and Pirri (1647). This is the Monastery of Saint Elias of Ambolà (the ruins of which lay today in the municipality land of Cesarò), that can be classified as "high damage" (HD; see Tab.1).

In the whole, casualties were at least 6, in addition to several dozens of injured, mostly in Cerami. Although few intensity datapoints can only provide a rough idea of the earthquake epicentral parameters, by using the algorithm BOXER4 (Gasperini et al., 2010) the epicentral intensity (Io) is 8 MCS, the magnitude from Io is Mw 5.57, and the epicenter is at coordinate N37°.79 - E14°.65 (see Tab. 2), that is a point very close to Troina where many ground fissures were observed by the inhabitants since the early foreshock in 1642. BOXER4 allows also to estimate the indicative length of the seismogenic faults, which in this case is 7 km, striking roughly E-W (N93°).

Certainly, the earthquake affected much more localities of the region, and it was likely felt in all the villages along the Tyrrhenian coast to the north, and in the Catania coast to the east. However, considering the deep destructions caused by the 1693 earthquakes, it is possible that the few documents attesting the far-field effects of the 1643 have been lost. Indeed, it is not by chance that the only reports that survived to this day are in Madrid, and concern only the most damaged area.

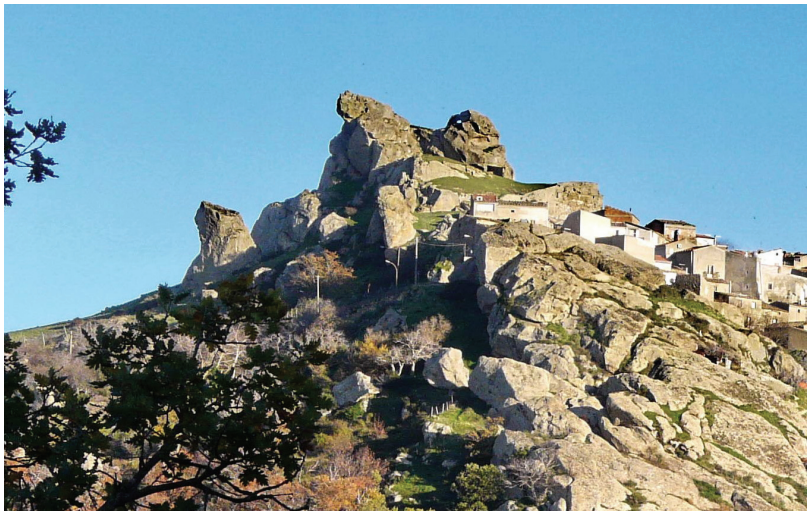


Fig. 8 - View looking east of the huge, massive sandstones toppling which affects the Cerami slopes, likely recalling the 1643 rock fall.

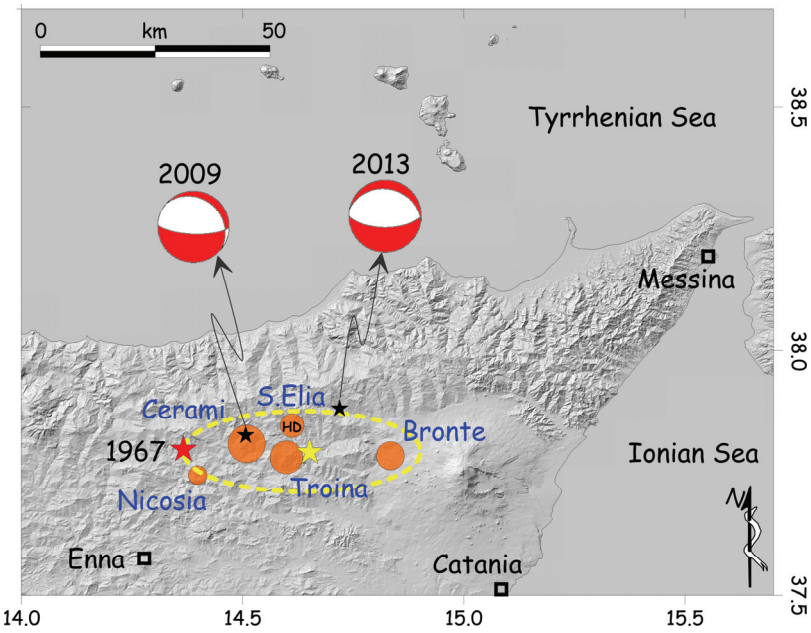


Fig. 9 - Orange circles, 1643 intensity datapoints distribution (dimension proportional to site intensity 6-7 to 8-9 MCS; HD, high damage. See Tab. 1 for analytics). Yellow star, epicenter estimated with BOXER4 algorithm. Dashed ellipse suggests the mesoseismic area. Red star is the instrumental epicenter of the 1967, Mw 5.0 earthquake. Black stars are the instrumental epicenters of the 2009 and 2013, Mw 4.4 events (focal mechanism from INGV-RCMT website page: http://www.bo.ingv.it/RCMT/).

3.2. Relationships with the regional seismicity

Considering the regional historical seismicity (Fig. 1), the 1643 can be considered the strongest event occurred in this area. In some villages, the 1643 effects were similar or even higher than in January 1693, the catastrophic earthquakes that razed to the ground dozen of towns in eastern Sicily, with damage from Malta to Palermo. For instance, in Troina, the houses and churches "*fracassate e dirupate*" (damaged and ruined; Relationes, 1693) by the 1693 event were 297 (*vs* a total of ~1000 buildings), indicating a site intensity close to the one assigned for the 1643 mainshock (i.e., 8 MCS degree).

On October 31, 1967 an event with Mb 4.9 (Margottini et al., 1993; ≈Mw 5.0) hit a conterminous sector of the Nebrodi area, damaging also Cerami, Nicosia and, above all, old and crumbling buildings in several villages and countryside toward the Tyrrhenian coast. Although this event is rated with an Io 8 MCS, it did not caused any casualties or injuries, whereas the informa-

Locality	Latitude	Longitude	Intensity
Cerami	37.810	14.509	8-9
Troina	37.783	14.599	8
Bronte	37.786	14.834	7-8
Nicosia	37.747	14.398	6-7
Sant'Elia di Ambolà	37.847	14.612	HD

Tab. 1 - MCS macroseismic intensities estimated for the 1643 earthquake (see Fig. 9).

tion deducible from the newspapers of the time accounts for a likely lower degree (7 MCS).

In turn, two smaller events (Mw 4.4) had their epicenters within the 1643 mesoseismic area in 2009, and 2013. Both did not produced damage (Io ≤5-6; Azzaro et al., 2014), and both were generated by crustal, E-W trending normal fault (see "beach balls" in Fig. 9), likely dipping southward. From a kinematic point of view, these focal mechanisms fit the prevailing ~N-S extension characterizing the Madonie and Nebrodi Mountains, as evidenced by the GPS velocity analyses in Palano et al. (2012) and by the geological indication collected by Pavano et al. (2015) toward the conterminous western Peloritani Mountain. Therefore, taking into account that the 1643 mesoseismic area is strongly elongated from Bronte to the east toward Nicosia to the west (yellow ellipse in Fig. 9), it is likely that the 1643 seismogenic structure is part of this E-W trending normal fault system.

3.3. Relationships between the seismic sequence and the Etna eruption

The volcanic triggering and interaction with the surrounding tectonics (e.g. in Eggert and Walter, 2009) is an endless issue studied by hundreds scholars since Darwin (1840). In the Etna region, the volcanic activity seems to be correlated to regional tectonic earthquakes (Sharp et al., 1981; Feuillet et al., 2006), as seismicity increases before the onset of flank and/or summit activity, being thus considered as a possible precursor to volcanic activity.

In 1643, beyond the continuous Etna roars resembling heavy artillery shells, and the huge ground deformations, the eruption took place from a mouth opened below the main crater and from another on the western flanks, toward Bronte. What I notice here is that while Randelli (1643a) reports the onset of the seismic sequence since August 1642 - with the two ~Mw 4.7 events in the nights of 21 and 22, followed by other strong foreshocks on June 21, 1643, and July 12 and 15 - the eruption is instead recalled on July 18, that is immediately after the mainshock of the same night. Therefore, it is likely that the foreshocks sequence and the mainshock itself predated the eruption which, subsequently, lasted until July 28, ending then prior to the aftershocks swarm that was still ongoing in mid August.

4. CONCLUDING REMARKS

The manuscripts perused at the National Library of Spain (Randelli, 1643a), together with another manuscript written by a friar of Tronia (Antonino da Troina, 1710), in addition to other documents (Pirri, 1647; *Avisos* in: Valladares de Sotomayor, 1790), have allowed to provide robust parameter to the previously little-known July 18, 1643 earthquake. This was the mainshock (Io 8 MCS, Mw 5.6) of a sequence started in August 1642 (21 -22 August; Io 6 MCS, Mw 4.72), which was also accompanied by a noticeable Etna activity. The news concern five localities roughly aligned in a E-W direction, the same trend of the normal faults that recently sourced a couple of Mw 4.4 earthquakes. The event caused heavy damage and collapses in Cerami, Troina and Bronte, where at least 6 persons died under the ruins and dozens were injured.

It is worth remembering that alongside historical high magnitude earthquakes (Mw>6.5) that occurred before the 14^{th}-13^{th} century (e.g., Galli and Peronace, 2014; 2015; Galli et al., 2015; 2016), our seismic catalogues missed or listed as lesser events several moderate earthquakes also during the late Middle Age and the early modern period (Castelli, 2003; Castelli and Camassi, 2005), especially in the former Kingdom of the two Sicilies (e.g. in: Albini and Rodriguez de la Torre, 1993;

Catalogue	Date	Lat N	Long E	Mm/Mw	Io	Np	Area
POS85	1643 07 17	37.67	14.67	4.7	7.0	0	M. SALICI
CPTI11	1643 07 17	37.783	14.599	4.93	6.5	1	TROINA
USSN	1642 08 21	37.79	14.65	4.72	6.0	1	TROINA
USSN	1642 08 22	37.79	14.65	4.72	6.0	1	TROINA
USSN	1643 07 18	37.79	14.65	5.57	8.0	4	TROINA

Tab. 2 - Epicentral parameters of the 1642-1643 earthquakes. Comparison among the records in Postpischl (1985; POS85), CPTI11 and this paper (USSN).

Castelli et al., 2008; Galli and Scionti, 2006; Scionti et al., 2006). As the Italian hazard maps are currently based on the historical seismic catalogue (CPTI2, i.e., an updated version of CPTI, 1999), these deficiencies imply a misleading computation of the seismic hazard, and thus of the associated risk. This is the case of the Nebrodi area, where the previously unknown 1643 event is either the strongest one ever occurred in this region (Mw 5.6) and the one which induced the highest intensities in many villages therein (up to 8-9 MCS).

ACKNOWLEDGMENTS

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