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Seismic history and hazard in some localities of south-eastern Sicily

M.S. BARBANO, R. RIGANO, M. COSENTINO and G. LOMBARDO

Dipartimento di Scienze Geologiche, Università di Catania, Italy

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Abstract - The effects of the main earthquakes which hit some localities of south-eastern Sicily were studied in detail in order to reconstruct the site seismic history and to evaluate the seismic hazard. The selected localities suffered destruction or heavy damage because of earthquakes located in the coastal sector of the Hyblean plateau. Besides this seismicity, the town of Nicolosi was heavily damaged by the events occurring in the Etna area as well. The great amount of available information, found in the historical sources and in the damage survey documents, allowed us to reassess the intensity according to the new 1998 European Macroseismic Scale. The seismic histories have been used to compute the hazard through seismic site observations. The resulting mean return periods appear generally shorter than those obtained using a classical approach such as Cornell's.

1. Introduction

The critical analysis of the intensity data sets available for some south-eastern Sicily localities (Augusta, Caltagirone, Catania, Lentini, Nicolosi, Noto, Ragusa, Siracusa) has been performed to define their site seismic history and by assessing the seismic hazard. The site catalogues have been compiled rereading the historical sources quoted in more recent studies (Boschi et al., 1995, 1997, 2000; Monachesi and Stucchi, 1997), and improved by adding further information about damage, especially for stronger earthquakes. To achieve homogeneity in the data sets, the collected information regarding earthquake effects, were interpreted and intensities were estimated using the 1998 new European Macroseismic Scale (EMS-98, Grünthal, 1998).

As regards the seismic hazard, several methods, such as the Cornell (1968) one, have been used in recent years in order to draw seismic hazard maps in the area (e.g. Slejko et al., 1998). These approaches are commonly affected by the assumption of homogeneous seismogenic

Corresponding author: M. S. Barbano, Dipartimento di Scienze Geologiche, Università di Catania, Corso Italia 55, 95129 Catania, Italy; phone: +39 957197729; fax: +39 957197712; e-mail: barbano@mbox.unict.it

zones having uniform seismic rate and attenuation model, which in practice determines the concealing of the site differences. In order to overcome these restrictions, seismic hazard has been estimated using site observed intensities, according to the methodology described by Magri et al. (1994).

2. The main damaging events

The epicentres of the regional earthquakes (Gruppo di Lavoro CPTI, 1999; Azzaro and Barbano, 2000; Barbano and Rigano, 2001) which damaged the selected localities (I ≥ V-VI EMS-98) are plotted in Fig. 1. The strongest earthquakes (1169, 1542, 1693, 1818, 1848 and 1990) occurred in the coastal area of the Hyblean Plateau and some of them were associated with the Malta Escarpment System (Azzaro and Barbano, 2000). This fault system, consisting of prevalent NNW-SSE trending normal fault segments, delimits the Ionian offshore zone (Bianca et al., 1999). Moderate magnitude earthquakes took place in the inner sector of the Hyblean Plateau. The town of Nicolosi also suffered the effects of local shocks, associated with the tectonic systems of the Etna volcano (Barbano et al., 2001).

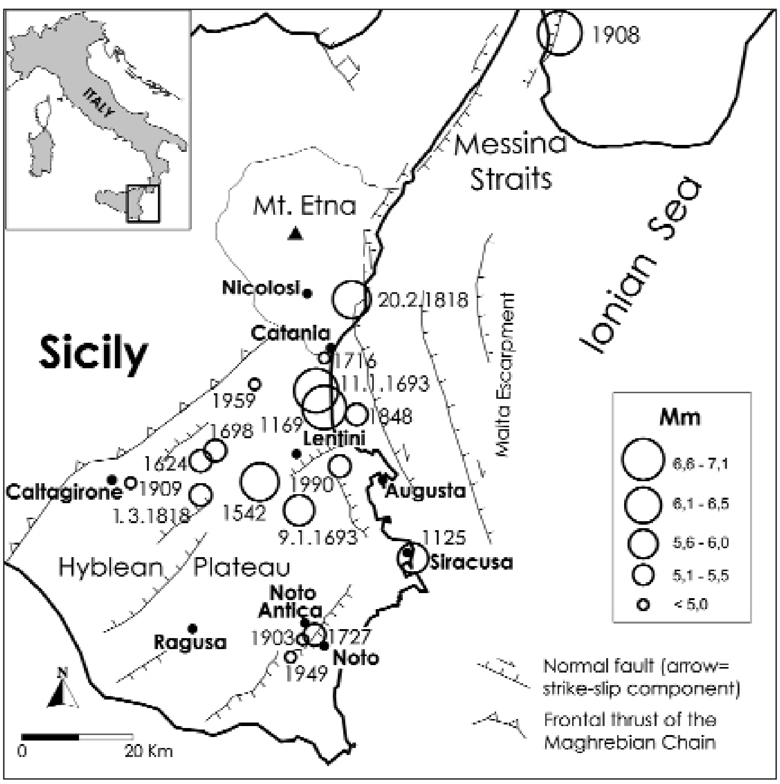

Fig. 1 - Epicentral map of the regional earthquakes which damaged the selected localities. M_m is the macroseismic magnitude computed according to the Rebez and Stucchi (1996) relationship. Main structural elements from Bianca et al. (1999).

Moreover, regional earthquakes, mainly related to the seismogenic sources of both the Messina Straits and South Calabria, caused minor damage in the investigated localities.

The brief description of damage caused by main earthquakes (I ≥ VII EMS-98) as well as the assessed intensities are provided for each locality. In many cases, owing to the indefiniteness and inadequacy of the damage reports, a range of intensity values was given (e. g. I = IX-X). The historical accounts frequently report detailed damage descriptions of monumental buildings whereas only generic information about ordinary buildings is supplied. The EMS-98 intensity estimates generally do not show significant differences with respect to the previously available MCS estimates, and usually the variations fall within the uncertainty range.

2.1. The earthquake on 4 February 1169

The 1169 earthquake, with estimated magnitude 6.6 (Gruppo di Lavoro CPTI, 1999), struck all eastern Sicily and part of southern Calabria, causing considerable damage (Boschi et al., 1995, 2000). All the most important villages and towns in Val di Noto (south-eastern Sicily), Piana di Catania (central part of eastern Sicily) and Val Demone (north-eastern Sicily) were heavily damaged (Fig. 2). Serious damage occurred to eleven castles and villages between Catania and Piazza Armerina (Chronaca Pisana, 1722) and to some castles close to Caltagirone (Aprile, 1725). Several permanent phenomena on the ground were observed in a wide area from the Ionian coast to Piazza Armerina. A tsunami affected the city of Messina and the Simeto river near Catania, and destroyed the village of Casal Simeto (Lombardo, 1985).

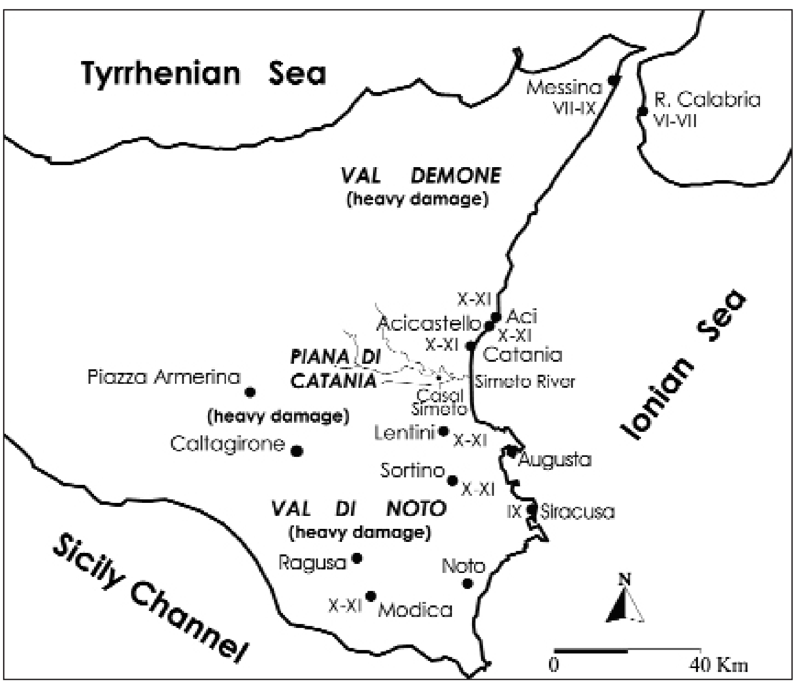

Fig. 2 - Macroseimic intensity (EMS-98) distribution map of 4 February 1169 earthquake.

It must be stressed that it is very difficult, considering the poor quality and the vagueness of the information reported in the sources, to ascribe the damage to an EMS-98 intensity value. Intensity X-XI was attributed to all localities for which sources report "total collapse" or "destruction". According to a chronicle of the XIII century (Chronaca Pisana, 1722) *"Catania civitas a terremotu subversa est usque ad fundamenta, et ex ea nec masculus nec femina evasit"* (the city of Catania was raised to the ground by the earthquake and not one man nor woman remained) (I = X-XI). The old site of Acireale, named Aci, was ruined (Vigo, 1836). The localities of Sortino, Lentini (Chronaca Pisana, 1722) (I = X-XI) and Modica (Romualdus Salernitanus, 1909-1935) were similarly destroyed. Part of the town of Siracusa (I = IX) was destroyed causing the death of some people (Romualdus Salernitanus, 1909-1935). Considering the extension of the damaged area, Augusta, Noto and Ragusa were probably also damaged, although they are not directly mentioned.

2.2. The earthquake on 10 December 1542

Damage caused by the 1542 earthquake extended from the Ionian coast, where several localities were nearly totally destroyed, as far as Caltagirone in the inner Hyblean plateau (Fig. 3).

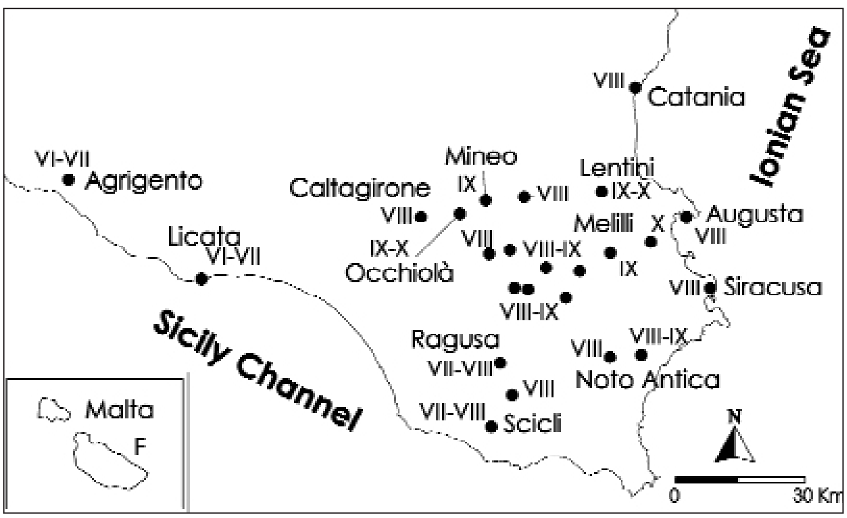

Fig. 3 - Macroseimic intensity (EMS-98) distribution map of 10 December 1542 earthquake.

Augusta and Noto Antica were heavily hit (I = VIII). Damage in Catania was also considerable and widespread (I = VIII). In Lentini about 70 people died and 900 houses ruined (I = IX-X) (Chronaca Siciliana, 1515-1574). According to Fazello (1560) almost all of Siracusa *"quasi tutta si commosse e rovinarono molte case"* (suffered damage and many houses ruined) (I = VIII). In Caltagirone (I = VIII) *"scissis muris, acclinatisque parietibus est labefactata"* (walls were broken and tilted, the town ruined) (Fazello, 1560). Ragusa was also afflicted (Garofalo, 1980).

2.3. The earthquakes on 9 and 11 January 1693

The 9 January foreshock (Barbano and Cosentino, 1981; Boschi et al., 1995, 2000) caused the greatest amount of damage in Augusta (I = IX), Lentini (I = VIII-IX), Noto Antica (I = VIII-IX), Melilli, Avola Vecchia and Floridia. In Siracusa the damage was strong (I = VII-VIII), whereas in Caltagirone the earthquake was strongly felt (I = V-VI).

Two days later, on 11 January the main shock caused destruction and serious damage in most localities of eastern Sicily, including the ones in the Etna area, such as Nicolosi (I = X), which was not damaged by the first shock (Boschi et al., 1995). Towns and villages located near the south-eastern coast of Sicily (among which are Augusta, Lentini, and Noto Antica) were entirely destroyed. For these localities an intensity X-XI has been assigned (Barbano and Rigano, 2001). As regards Siracusa (I = IX-X), Boccone (1697) describes the effects as follows *"Non si può dire tutta distrutta dai fondamenti, ma si sono rovinate case, conventi e chiese"* (One cannot say that it is totally destroyed to the ground, but the houses, convents and churches are ruined). Similar descriptions were found for Ragusa Ibla, e.g. Boccone (1697) reports: *"rimase in piedi circa d'una terza parte"* (about one third of the town remained standing) (I = IX-X). In other cases, the damage scenario is better defined. For instance, as regards Caltagirone, an extensive damage information is available (Boscarelli, 1977) so that I = IX EMS-98 was estimated.

2.4. The earthquakes on January and April 1698

Descriptions of the 1698 earthquakes were previously available (Monachesi and Stucchi, 1997) only from both Mongitore's historical catalogue (1743) and by "Mercure historique et politique" (1698), which refer that Catania, Vizzini and Militello were damaged and the shock was strongly felt in Palermo.

New information concerning this event is reported in Boscarelli (1977) and regards the town of Caltagirone, that *"si fracassò e restò aperta come un granato (melograno) e cascarono moltissime case, et il resto della Città è malamente che si sta consando (riparando)"* (ruined and remained open like a pomegranate, several houses collapsed. The remaining part of the town is heavily damaged). About 20 people died. According to Mongitore, in Catania *"alcune case rovinarono, con l'oppressione di alcune poche persone"* (some houses ruined and a few people died).

Some contradictory information was found in the historical sources. Tortora (1972) refers to three shocks dated 11 January 1698, felt in Noto as well. Mongitore (1743) reports that two different shocks occurred on 1 January 1698 and 12 April, causing damage in the previously mentioned localities. On the other hand Boscarelli (1977) ascribes the damage only to the 1 January shock, although he refers to other shocks occurring on 12 and 19 April. The last information seems to be the most reliable, because Boscarelli was a witness of the event, whereas Mongitore wrote from Palermo, assembling information from other chroniclers. The date reported by Tortora is in our opinion probably wrong since he might have confused it with the date of the 1693 shock.

However, as concerns the topic of present study, it is important to point out the bad state of the houses, that were already seriously damaged by the 1693 earthquakes. For this reason the description of damage in Caltagirone, Catania, Vizzini and Militello is ascribed an intensity VII-VIII (Fig. 4).

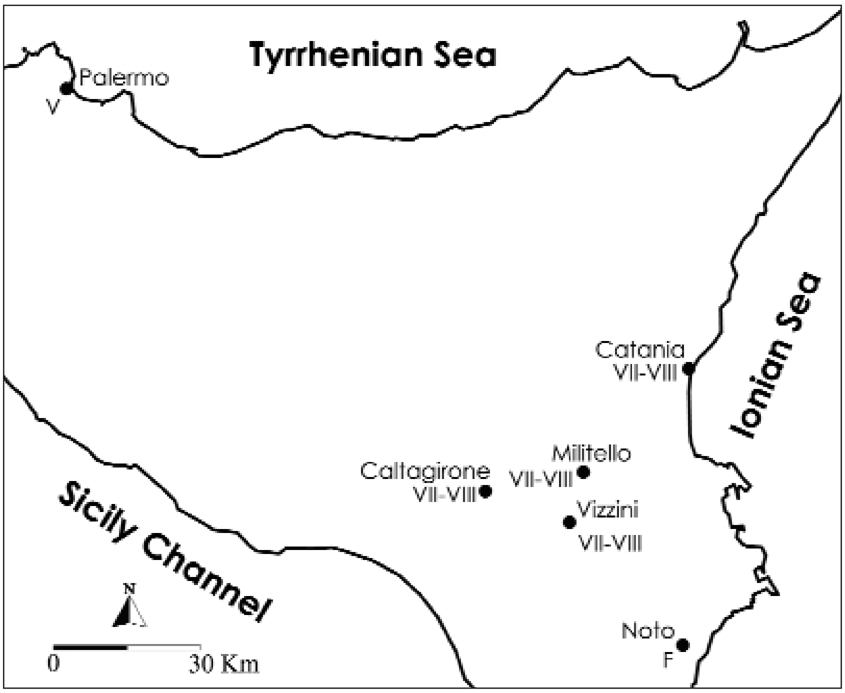

Fig. 4 - Macroseimic intensity (EMS-98) distribution map of 1 January 1698 earthquake.

2.5. The earthquakes on 20 February and 1 March 1818

The 20 February 1818 event produced heavy damage and ruins in many localities of the Etna region, whereas it caused moderate damage in many localities of eastern Sicily (Boschi et al., 1995). It was felt strongly all over Sicily and slightly in southern Calabria, almost all the Eolian islands and as far as the island of Malta. This earthquake is currently interpreted as a crustal earthquake generated by the northernmost segment of the Malta Escarpment system (Azzaro and Barbano, 2000).

Nicolosi, located in the Etna southern flank, was seriously damaged (I = VIII) (Barbano et al., 2001). Catania suffered moderate damage (I = VII) as well, whereas in Lentini and Caltagirone slight damage was observed (I = VI). The shock was strongly felt in Augusta, Siracusa and Noto (Boschi et al., 1995).

As regards the 1 March event, located in the Vizzini - Licodia area, it caused moderate damage in Ragusa, Caltagirone and Lentini (I = VII) and slight damage in Catania (I = VI) (Boschi et al., 1995).

2.6. The earthquake on 11 January 1848

The 1848 earthquake struck some localities of south-eastern Sicily, causing heavy damage especially in the area between Augusta and Catania along the Ionian coast (Monachesi and Stucchi, 1997; Boschi and Guidoboni, 2001). The largest damage was observed in Augusta, where almost two thirds of the buildings collapsed and 30 people died (Ferruggia Russo, 1852) (I = IX). Catania suffered significant and widespread damage (Cristoadoro, 1848) (I = VII-VIII). In Siracusa and Noto many buildings suffered cracks (Ferruggia Russo, 1852) (I = VI-VII). In Ragusa the earthquake was just felt (I = IV).

2.7. The earthquake on 13 December 1990

The 1990 earthquake affected about 250 localities in the provinces of Siracusa and Catania and was also felt in some localities of southern Calabria (Boschi et al., 1997). Although the shock was of moderate magnitude (M = 5.3), it caused victims and widespread damage in the north-eastern sector of the Hyblean area. In Augusta heavy damage was observed in some reinforced concrete buildings (I = VII-VIII) located on the outcrop of very soft sediments, derived from an ancient salt-pit. In Lentini many reinforced concrete buildings suffered extensive cracks (I = VII). Damage was slight to moderate in Siracusa (I = VI-VII), slight in Catania, Ragusa, Caltagirone and Noto (I = VI). The event was also strongly felt (I = V) in Nicolosi.

3. The site catalogues

In Table 1 the observed data for the 37 earthquakes which have produced effects greater or equal to intensity VI EMS-98 in at least one of the studied localities are reported. In order to evaluate the completeness of the site catalogues and to improve their reliability, virtual site intensities (I_{cal}) have been calculated using the parametric Italian Catalogue (Gruppo di Lavoro CPTI, 1999) and the cubic attenuation model proposed by Magri et al. (1994). This implies considering 6 more earthquakes that might have caused I ≥ VI in one of the studied localities and several shocks that were just felt (Fig. 5). The site seismic histories obtained through the mentioned integration, similarly to the parametric earthquake catalogue, show a lack of information before the 16th century. For the 1125 and the 1169 earthquakes, damage information is available just for Siracusa, Catania and Lentini. As regards the events below the damage threshold (I ≤ V-VI), the catalogue seems complete beginning from the end of the 19th century. Both destructive and damaging earthquakes in south-eastern Sicily are not frequent. All the localities were destroyed during the 1693 earthquakes, and some of them were ruined or strongly damaged by the 1169, 1542, 1698, 1727, 1818, 1848 and 1990 events. Nicolosi was also nearly destroyed in 1633 and 1669 and more or less heavily damaged several times because it is affected by the local seismicity due to the Etna tectonic structures (Barbano et al., 2001).

Table 1 - Main damaging earthquakes in SE Sicily and observed intensities in the considered localities. Mm is the macroseismic magnitude computed according to the Rebez and Stucchi (1996) relationship. Data marked with (^) are retrieved from the Gruppo di Lavoro CPTI (1999), those marked with (*) from Azzaro and Barbano (2000) and those marked with (˜) from Barbano and Rigano (2001). Data revised in this study are reported in italics. Other earthquakes are retrieved from Azzaro et al. (2000).

Ye Mo Da	Epicentral Area	Lat	Lon	M_m	I_o	I_{obs} Augusta	I_{obs} Caltagirone	I_{obs} Catania	I_{obs} Lentini	I_{obs} Nicolosi	I_{obs} Noto	I_{obs} Ragusa	I_{obs} Siracusa
1125 06 07^	Siracusa	37.070	15.300	5.8	VIII-IX	-	-	-	-	-	-	-	VIII-IX
1169 02 04	Eastern Sicily	37.380	15.070	6.8	X-XI	-	-	X-XI	X-XI	-	-	-	IX
1542 12 10˜	Sortino	37.227	14.903	6.3	IX-X	VIII	VIII	VIII	IX-X	-	VIII	VII-VIII	VIII
1536 03 23	Etna	37.750	15.000	3.9	VII-VIII	-	-	-	-	VII-VIII	-	-	-
1624 10 03^	Mineo	37.270	14.750	5.4	VIII	-	VI	-	-	-	-	-	-
1633 02 21	Nicolosi	37.600	15.017	4.8	VIII-IX	-	-	-	-	VIII-IX	-	-	-
1669 03 10	Nicolosi	37.600	15.017	4.8	VIII-IX	-	-	-	-	IX	-	-	-
1693 01 09˜	Val di Noto	37.169	15.005	5.8	VIII-IX	IX	V-VI	VIII	VIII-IX	-	VIII-IX	-	VII-VIII
1693 01 11˜	Eastern Sicily	37.415	15.049	6.8	X-XI	X-XI	IX	X-XI	X-XI	X	X-XI	IX-X	IX-X
1698 04 12	Vizzini	37.292	14.789	5.1	VII-VIII	-	VII-VIII	VII-VIII	-	-	F	-	-
1716 12 01^	Catania	37.502	15.087	4.8	VII	-	-	VII	-	-	-	-	-
1727 01 07^	Noto	36.913	15.045	5.1	VII-VIII	III-IV	-	-	-	-	VII-VIII	-	III-IV
1818 02 20˜	Catania Area	37.602	15.141	6.3	IX-X	V	VI	VII	VI-VII	VIII	V	VI	V
1818 03 01^	Hyblean Mt.	37.200	14.750	5.1	VII-VIII	-	VII	-	VII	-	-	VII	-
1832 11 24	Nicolosi	37.614	15.026	3.7	VII	-	-	-	-	VII-VIII	-	-	-
1848 01 11˜	Augusta	37.366	15.154	5.4	VIII	IX	-	VII-VIII	-	-	VI-VII	IV	VI-VII
1883 03 22	Nicolosi	37.653	15.065	4.1	VIII	-	-	-	-	VII-VIII	-	-	-
1883 03 22	Belpasso	37.602	15.003	3.7	VII	-	-	-	-	VI-VII	-	-	-
1883 03 26	Nicolosi	37.614	15.026	3.5	VI-VII	-	-	-	-	VI-VII	-	-	-
1883 04 05	Nicolosi	37.679	15.058	3.4	VI	-	-	-	-	VI	-	-	-
1883 04 28	Nicolosi	37.614	15.026	3.5	VI-VII	-	-	-	-	VI-VII	-	-	-
1885 09 25	Nicolosi	37.614	15.027	3.7	VII	-	-	-	-	VII	-	-	-
1885 10 02	Nicolosi	37.614	15.026	3.5	VI-VII	-	-	-	-	VI-VII	-	-	-
1893 03 31	Nicolosi	37.614	15.026	3.4	VI	-	-	-	-	VI	-	-	-
1898 11 02	Caltagirone	37.216	14.495	4.3	VI	III	VI	III	-	-	-	III	-
1901 05 11	Nicolosi	37.617	15.029	3.7	VII	-	-	-	-	VII	-	-	-
1901 05 11	Nicolosi	37.615	15.023	3.4	VI	-	-	-	-	VI	-	-	-
1903 02 10^	Noto	36.903	15.014	4.3	VI	-	-	-	-	-	VI	-	IV
1908 12 28^	Messina Area	38.150	15.680	7.1	XI	VII	VII	VI	VII	VII	VI	-	VI
1909 01 02*	Caltagirone	37.231	14.520	4.4	VI	-	VI	-	-	-	-	-	-
1942 11 15	Nicolosi	37.614	15.029	3.5	VI-VII	-	-	-	-	VII	-	-	-
1949 10 08*	Modica	36.867	14.983	4.8	VI-VII	-	VI	V-VI	-	-	-	-	-
1959 12 23*	Catania Plain	37.428	14.890	4.7	VI-VII	-	V-VI	VI	V	VI-VII	-	-	-
1974 05 18	Nicolosi	37.615	15.029	3.2	V-VI	-	-	-	-	VI	-	-	-
1986 01 29	Nicolosi	37.613	15.026	3.3	VI	-	-	-	-	VI-VII	-	-	-
1990 12 13˜	SE Sicily	37.259	15.110	5.1	VII-VIII	VII-VIII	VI	VI-VII	VII	V	VI	VI	VI-VII

In the town of Caltagirone the occurrence of slight damage is more frequently observed with respect to the other sites because the town is also affected by the north-western Hyblean plateau seismicity of magnitude ≤ 5.5 (Azzaro and Barbano, 2000).

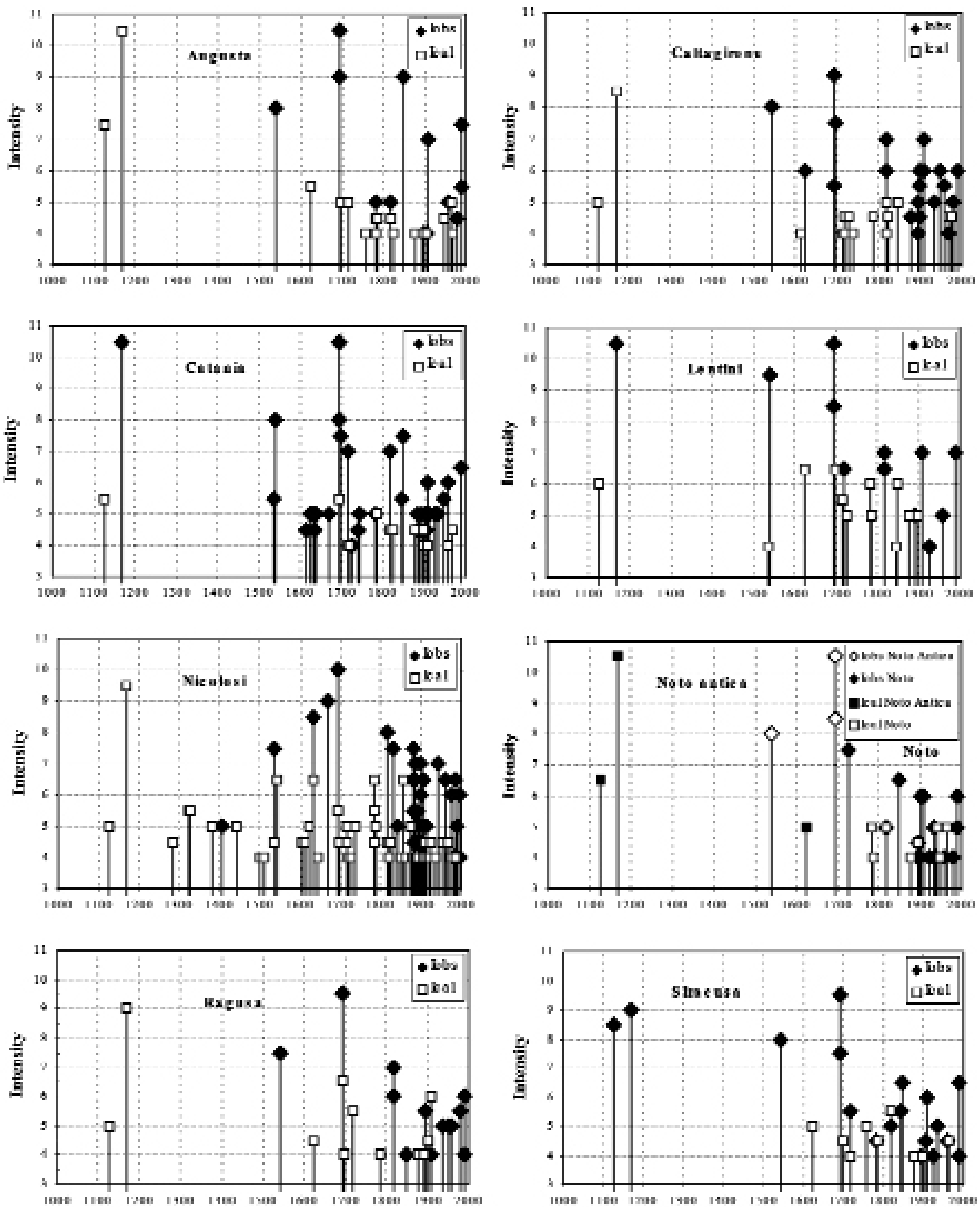

Fig. 5 - Site seismic histories of the selected localities (I ≥ IV EMS-98). I_{obs} are observed intensities, I_{cal} are intensities obtained using the parametric Italian catalogue and an attenuation law (see text).

4. Hazard assessment

The site seismic histories have been used to estimate seismic hazard through the procedure proposed by Magri et al. (1994). This approach is based on the use of a discrete distribution function describing, for each earthquake, the probability that site effects are greater than, or equal to, each possible intensity value of the adopted macroseismic scale. The probability function can be defined using available macroseismic data at the site. As an example, if uncertainty is assumed to exist only between the two possible intensities VII and VIII, the distribution function could be described by the ten elements array

$$p_s(I) = [1.,1.,1.,1.,1.,1.,0.5,0.,0.,0.]$$

for intensity I ranging between the degrees II and XI (EMS-98).

When observed data are lacking, the dependence of this distribution function on the distance *r* from the epicentre and on the epicentral intensity can be modelled either by a probability function (see Magri et al., 1994), or substituting values derived by an attenuation relationship. In this formalisation, site seismic history results in an array of distribution functions representing, for each earthquake, the probability that at the site the intensity is greater than, or equal to, each

Table 2 - Completeness starting year for each intensity class and corresponding mean return period with associated error.

Int	*Augusta*		*Caltagirone*		*Catania*		*Lentini*	
	Complete since	Return period	Complete since	Return period	Complete since	Return period	Complete since	Return period
IV	1878	5.8 ± 1.1	1818	7.1 ± 1.8	1878	6.1 ± 1.4	1818	9.3 ± 2.2
V	1783	16 ± 4	1818	13 ± 3.3	1783	15 ± 4.2	1783	15 ± 4
VI	1693	30 ± 11	1693	36 ± 17	1693	28 ± 8.6	1693	29 ± 10
VII	1542	60 ± 27	1542	85 ± 35	1693	41 ± 12	1542	63 ± 28
VIII	1542	94 ± 43	1542	150 ± 70	1542	98 ± 44	1542	102 ± 49
IX	1169	242 ± 145	1169	466 ± 176	1169	254 ± 151	1169	235 ± 143
X	1000	556 ± 394	1000	792 ± 540	1000	553 ± 324	1000	498 ± 312
Int	*Nicolosi*		*Noto*		*Ragusa*		*Siracusa*	
	Complete since	Return period	Complete since	Return period	Complete since	Return period	Complete since	Return period
IV	1883	2.0 ± 0.2	1878	8.2 ± 1.8	1878	8.1 ± 1.7	1878	7.4 ± 1.4
V	1818	3.4 ± 0.6	1783	21 ± 6	1783	19 ± 5	1757	20 ± 5
VI	1783	6.6 ± 1.2	1693	37 ± 11	1693	41 ± 15	1693	38 ± 15
VII	1536	33 ± 5	1693	62 ± 21	1542	96 ± 44	1542	78 ± 36
VIII	1536	72 ± 34	1542	140 ± 72	1542	155 ± 84	1542	127 ± 62
IX	1169	266 ± 60	1169	368 ± 273	1169	432 ± 385	1169	341 ± 238
X	1000	644 ± 380	1000	683 ± 569	1000	773 ± 570	1000	678 ± 556

intensity value. The return period with its associated error and the probability that in a given period the site intensity will be greater than, or equal to, a fixed intensity, can be therefore estimated. An exhaustive description of the numerical procedures used here, is reported in Mucciarelli et al. (1992) and Magri et al. (1994). It should be stressed that, for nearly all the events, most of the intensity values used in the computation come from the observed values. Therefore, especially for the damaging shocks, the attenuation model adopted is practically negligible. Furthermore, each intensity class has its own completeness threshold and is treated independently from the other classes, that is, no a priori model (e.g., Gutenberg-Richter, etc.) was used.

The completeness of the site catalogues was tested using the methodology proposed by Mulargia et al. (1987). Table 2 gives the completeness starting year for each intensity class and the mean return periods (Fig. 6) for all the above mentioned localities. Caltagirone and Ragusa,

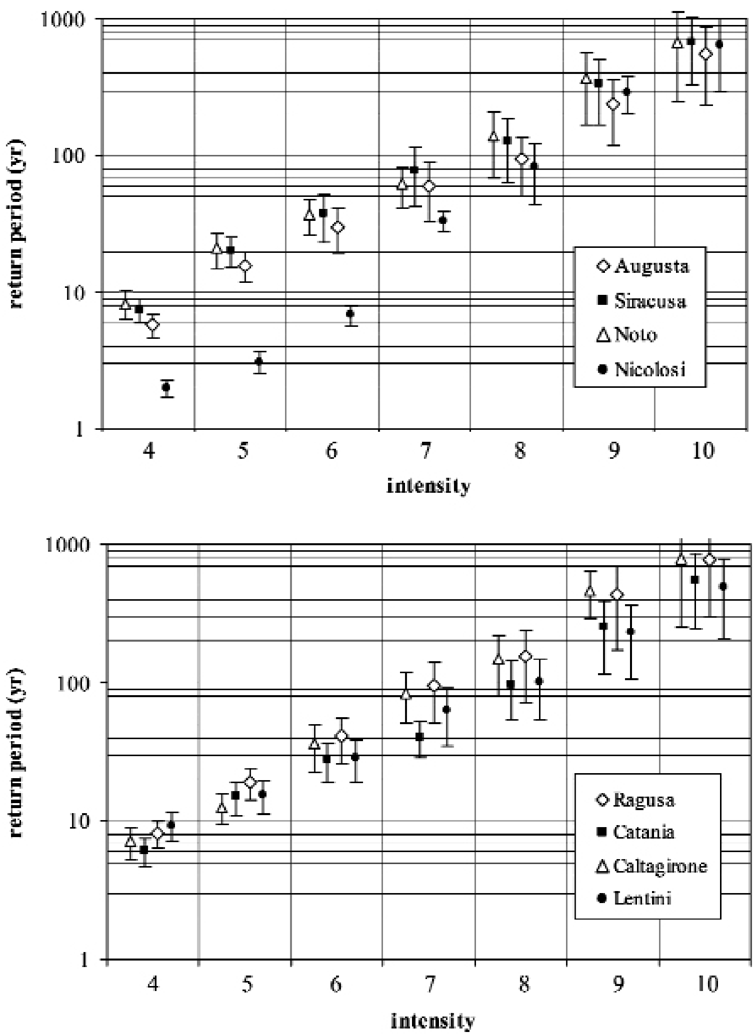

Fig. 6 - Mean return times with associated error for the studied sites, estimated according to the methodology by Magri et al. (1994).

located in the inner part of the Hyblean plateau, have the longest return periods for intensity higher than VII. In the coastal sector (Lentini, Catania and Augusta) there is a higher probability of occurrence for destructive events, whereas Siracusa and Noto have relatively low occurrence probability. Nicolosi shows the shortest return periods for intensities equal to, or lower than, VII, as a consequence of the frequent local Etna seismicity. However, the return times of destructive events are similar to those of the other localities.

The mean return periods, computed using the site intensities, are generally shorter than the ones obtained with the Cornell (1968) method (Slejko et al., 1998). Such a method, for instance, gives VIII as the intensity with a 475-year return period in most south-eastern Sicily localities, whereas our results estimate intensity IX, and sometimes X, for a comparable time interval (Fig. 6). On the other hand and in the same time span, the Cornell (1968) method postulates an intensity X for Nicolosi. Our estimate for intensity X is 644 years with an extremely high associated error. These differences cannot be justified by the small changes detected between intensities estimated with EMS-98 scale and the MCS one. This most likely is a consequence of the assumption, in the Cornell method, of an a priori earthquake distribution based on local seismicity rate. Actually, earthquakes in Nicolosi are frequent but not destructive (Barbano et al., 2001) and intensity X was observed just once.

5. Concluding remarks

For some localities in south-eastern Sicily the site seismic history was compiled, with the final goal of evaluating their seismic hazard. Several historical sources, especially for the 1693 earthquakes, supplied a great amount of information to assess intensities according to the EMS-98.

As a result of the present study, the following conclusions can be drawn.

- The site catalogues show that both destructive and damaging earthquakes did not frequently affect the selected localities.
- The adopted methodology allowed us to discriminate a spatial variability in the site seismic hazard values. Such variations are not so evident when classic approaches are used, because they usually tend to uniform hazard in large areas. The method used here deals mostly with observed intensities and it is therefore not affected by both the earthquake distribution law, and seismogenic zone contouring. A moderate influence on the hazard estimate might be given by the choice of the attenuation model.
- The hazard estimated in Nicolosi (Etna area) is comparable to hazard computed in the other Sicilian localities for destructive earthquakes (I = X). The return periods of moderately damaging earthquakes are shorter than those obtained for the remaining sites, because of the frequent low-magnitude seismicity which affected the town.
- The highest probability of occurrence for destructive shocks was estimated for the sites of Catania, Lentini and Augusta. This indirectly suggests that, although the analysis has been performed in a limited number of localities, the most active seismogenic sources are probably located close to this portion of the Ionian coast.

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