



**ACCEPTED ON ANNALS OF GEOPHYSICS, 62,
2019; Doi: 10.4401/ag-8175**

**EARTHQUAKES AND GHOST TOWNS IN SICILY: FROM
THE *VALLE DEL BELICE* IN 1968 TO THE *VAL DI NOTO* IN
1693. THE FIRST STAGE OF THE VIRTUAL SEISMIC
ITINERARY THROUGH ITALY**

Raffaele Azzaro^{1*}, Massimiliano Cascone², Alfio Amantia¹

(1) Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Catania, Italy

(2) Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy

1 “EARTHQUAKES AND GHOST TOWNS IN SICILY: FROM THE VALLE DEL BELICE IN 2 1968 TO THE VAL DI NOTO IN 1693. THE FIRST STAGE OF THE VIRTUAL SEISMIC 3 ITINERARY THROUGH ITALY,”

4
5 Raffaele Azzaro^{1*}, Massimiliano Cascone², Alfio Amantia¹

6
7 ⁽¹⁾ Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Catania, Italy

8 ⁽²⁾ Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy
9

10 11 ABSTRACT

12 Destructive earthquakes leave traces not only on the physical landscape but also on human processes. Among the most
13 devastating consequences is the abandoning of towns and villages, in favour of locations deemed safer. Abandoning a
14 village and resettling in a new location, whether a gradual process or the result of a sudden traumatic situation, is an
15 event of great historical, cultural and anthropological impact. It entails the loss of a piece of history or culture – local
16 identity – and the more suddenly it happens, the more dramatic the after-effects. Italy has almost two hundred localities
17 that have been abandoned for different causes (landslides, floods, volcanic eruptions, but also social or environmental
18 reasons), some ninety of them owing to earthquakes. Sicily, a land of volcanoes and earthquakes, has several traces of
19 former villages either in the form of fairly substantial ruins or even half-destroyed, which are usually located a few
20 kilometres away from the new settlements. In this paper, we present the methodological approach developed in the
21 framework of the EDURISK Project to enhance the awareness of seismic risk as an element of daily life; the case-study
22 of the *Valle del Belice* after the 1968 earthquakes represents the richness and complexity of this approach well.
23 Following this rationale, in 2006, we published the first multimedia product devoted to Sicily based on the tools
24 available at that time: a DVD-Rom hosting the interactive Quick Time™ Virtual Reality format. Today, multimedia
25 technology is much more advanced and web-oriented, but the methodological approach is still valid.
26
27

28 1. INTRODUCTION

29 Destructive earthquakes leave deep scars on the territory, both on the physical landscape (e.g.
30 large landslides) and on society. One of the most striking effects is the abandonment of villages and
31 towns, even important ones, in favor of new ones believed safer with respect to the causative event
32 or also more suitable for the changed social-economic conditions [e.g. Camassi, 2004]. Abandoning
33 a town and resettling the community in a new site, whether as result of a process over time or of a
34 sudden traumatic situation, is an event of wide historical, cultural and anthropological impact [e.g.
35 Teti, 2004]. Indeed, in many cases it leads to the loss of a piece of local history and culture,
36 especially when the change is rapid.

37 Abandoned settlements are therefore the most spectacular testimonies to the fragility of the
38 territory. Better than any other evidence, they show the impact of a seismic event on the life of a
39 community. For this reason, their rediscovery is a unique opportunity from a cultural standpoint to
40 enhance the awareness of seismic risk as an element of daily life [Bitelli et al., 2000a]. This
41 rationale has been developed in the framework of the EDURISK Project (Earthquake eDUcation: an
42 investigative journey into seismic RISK reduction, www.edurisk.it), funded since 2002 by the
43 Italian Civil Protection Department [Camassi et al., 2005; Pessina and Camassi, 2012].

44 One of the main tasks of the project was to prepare a series of virtual journeys through the traces
45 left by past destructive earthquakes in Italy [Azzaro, 2012]. In this paper, we present the first
46 interactive multimedia (DVD) created on a regional scale, devoted to the virtual navigation
47 throughout the seismic itineraries of Sicily [Azzaro et al., 2006]. As a prototype for other
48 earthquake-prone regions, it has been designed as a multidisciplinary tool to document features and

49 effects of the earthquakes, their social impact and reconstruction dynamics; information on the
50 seismic classification is also provided. In the following, the criteria and methodological approach
51 applied in this work are described in detail together with some cultural aspects resulting from the
52 critical reading of the materials.

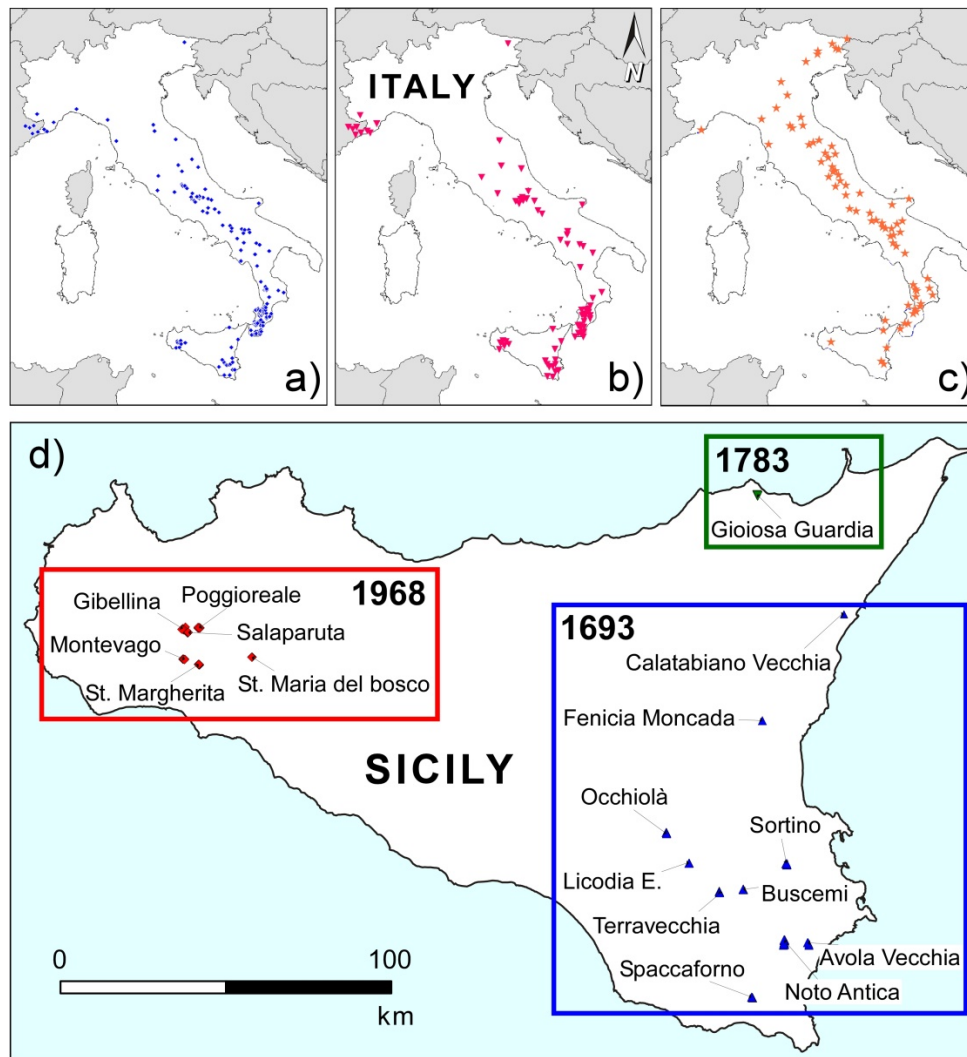
53
54

55 **2. DESERTED SETTLEMENTS IN ITALY: A BRIEF OVERVIEW**

56 A detailed investigation on a wide range of historical sources and recent studies was the first step
57 to obtain a preliminary inventory of abandoned settlements throughout Italy [Camassi, 2004]. As a
58 result, nearly two hundred localities were recognized as having been abandoned for different natural
59 causes including, in order of importance, landslides, floods, earthquakes and volcanic eruptions, but
60 there are also situations determined by long-lasting effects due to environmental and anthropic
61 reasons (Figure 1a). For example, the defensive position of the medieval villages on the top of hills
62 was no longer necessary after the 17th century and new towns were established in better sites for
63 trading and farming [Klapisch-Zuber, 1973]. One clue to such a process is the frequency, in the
64 Italian territory, of place names tagged with “*vecchio*” or “*antico*” (old) or “*nuovo*” (new).

65 Overall, some ninety settlements were abandoned as a consequence of earthquakes, although in a
66 few cases this was not the sole cause. Traces of the ancient sites are of archaeological type, usually
67 identifiable a few kilometres away from the new towns and visible in the form of more or less
68 evident isolated remains or settlements in ruins (since the late 1800s). Most of them are located in
69 Central and Southern Italy (Figure 1b), namely in regions prone to destructive earthquakes,
70 especially in connection with the great seismic sequences occurring in 1703 in the Central
71 Apennines, 1783 in Calabria and 1693 in Eastern Sicily (Figure 1c). Two very apparent spots of
72 deserted localities appear at the extremities of the peninsula: the first in north-west Italy at the
73 border with France, where the abandonment was caused by the M6.3 1887 earthquake; the second
74 in Western Sicily as a consequence of the 1968 Valle del Belice earthquakes.

75



76

77 **Figure 1.** (a) Location of the towns and villages abandoned in Italy as a consequence of natural phenomena and other
 78 anthropic causes. (b) Localities deserted following destructive earthquakes. (c) Distribution of $M \geq 6.0$
 79 earthquakes according to the CPTI15 catalogue [Rovida et al., 2016]. (d) Ghost towns in Sicily; dates refer
 80 to the earthquakes responsible for the abandonment of the sites.

81

82 3. GHOST TOWNS IN SICILY: A JOURNEY THROUGH TIME

83 In Sicily, the case-studies regard very different situations, both from the historical viewpoint of
 84 the period concerned and the geo-anthropological features of the affected areas; in all, 17 sites
 85 which underwent total or partial resettlement have been identified (Figure 1d). In particular, six
 86 ghost towns are related to the “recent” 1968 seismic period in Western Sicily (namely *Valle del*
 87 *Belice*) [Gangemi and La Franca, 1979], occurring in an area considered poorly seismic up until this
 88 date. The largest group of abandoned settlements (10 sites) is associated with the 1693 earthquakes,
 89 one of the main Italian seismic catastrophes that caused extensive destruction in the towns of
 90 Eastern Sicily (also known as *Val di Noto*) [Dufour and Raymond, 1994]. Finally, the case-study
 91 presented for North-eastern Sicily is unique since the abandonment is a consequence of the
 92 earthquakes devastating Southern Calabria in 1783 [Principe, 2001]. Linking the abandonment to
 93 the causative earthquake, we have grouped these ghost towns into three distinct macro-areas,
 94 namely the 1693 *Val di Noto*, 1783 *Val Dènone* and 1968 *Valle del Belice* (Table 1).

Deserted locality	Inhabitants before abandonment	Coordinates Lat - Long	Altitude (m a.s.l.)	Distance from the new site (km)	New settlement	District
Val di Noto						
Avola Vecchia	6000	36.9354 - 15.1085	400	4	Avola	Syracuse
Buscemi	2200	37.0834 - 14.8847	760	0,3	Buscemi	Syracuse
Calatabiano Vecchia	800	37.8292 - 14.9496	210	1	Calatabiano	Catania
Fenicia Moncada	1600	37.5408 - 14.9496	250	6	Belpasso	Catania
Licodia	3000	37.1548 - 14.6993	580	adjacent	Licodia Eubea	Catania
Noto Antica	12000	36.9412 - 15.0237	409	7	Noto	Syracuse
Occhiolà	3000	37.2369 - 14.6230	480	7	Grammichele	Catania
Sortino Vecchia	6000	37.1535 - 15.0326	380	0,5	Sortino	Syracuse
Spaccaforo	8000	36.7908 - 14.9157	170	1	Ispica	Ragusa
Terravecchia	3000	37.0779 - 14.8025	770	3	Giarratana	Ragusa
Valle del Belice						
Gibellina	5800	37.7880 - 12.9743	450	10	Gibellina nuova	Trapani
Montevago	3000	37.7072 - 12.9740	380	1	Montevago nuova	Agrigento
Poggioreale	2700	37.7917 - 13.0270	400	7	Poggioreale nuova	Trapani
Salaparuta	2800	37.7789 - 12.9887	385	5	Salaparuta nuova	Trapani
Santa Margherita	7000	37.6928 - 13.0267	420	0,3	Santa Margherita	Agrigento
S. Maria del bosco	-	37.7132 - 13.2067	827	abandoned	S. Maria del bosco	Palermo
Val Dènone						
Gioiosa Guardia	450	38.1512 - 14.9314	803	10	Gioiosa Marea	Messina

Table 1. Inventory of the towns abandoned after earthquakes in Sicily.

95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119

In general, the deserted settlements presented here show heterogeneous characteristics also within the same group, firstly with respect to how they appear today. In the *Valle del Belice*, in only a couple of cases, such as Poggioreale and Santa Margherita, is the field evidence still impressive, while at the other localities the remains are quickly disappearing despite the short time elapsed since 1968. This is largely due to the complete lack of preservation measures to counteract the theft of the few remains and the dismantling action of vegetation. Secondly, there is the different size of the settlements. These range from important towns such as Noto Antica - the old administrative capital of the wealthy *Val di Noto* from the Arab period till the 1693 earthquakes – to mountain villages, but also a few isolated ruins with a certain relevance from the historical and artistic points of view. Among them, we have documented the Benedictine abbey of S. Maria del bosco, the Capuchin convent of Buscemi, the stronghold of Spaccaforo, examples of small pearls of the Sicilian cultural heritage exposed to seismic risk.

Finally, special mention should be given to Fenicia Moncada, a settlement located at the extreme southern periphery of the Etna region. This case study represents a perfect example of the ways in which a single community reacted to extreme natural events, such as the 1669 Mt. Etna eruption and the 1693 *Val di Noto* earthquakes [Branca et al., 2015]. After the original village of Malpasso was completely buried by the lava, the new settlement of Fenicia Moncada was built in a position sufficiently far from the volcano to make it unlikely to be affected by future eruptions. Although it was not destroyed by the 1693 earthquakes, the local community decided to transfer the village back again to the slopes of the volcano, not far from the former site (today Belpasso). A rare case of reconstruction repeated three times in less than fifty years, testifying to how a small community seeks to maintain their identity with a particular place, despite its hazardousness.

120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141

4. DOCUMENTING ABANDONED SITES: METHODOLOGICAL APPROACH

The second step of our work was to collect different kinds of materials in order to fully document the selected sites. Traces of seismic catastrophes can be found in the local history (when, how), traditions (religious rites), but also architecture (construction techniques). Our general guideline was to show abandoned towns as they were before the abandonment compared with the archaeological remains visible today, and to analyse the earthquakes' impact on the community that determined the resettlement in a new site. An approach linking, in practice, the past and present of a community in its own territory.

The macro-areas investigated in Sicily represent highly heterogeneous situations from the view point of documentary data typologies. This mostly depends on the historical period analysed. For example, in the cases of the 1693-1783 earthquakes sources of relevant information include both descriptions by contemporary witnesses and iconographic material of the considered settlements (maps, pictures and paintings), while for the "recent" 1968 *Valle del Belice* earthquakes there is a rich multi-disciplinary bibliography as well as many photographs and videos (Figure 2).

Finally, the current condition of the abandoned sites has been documented by a detailed photographic survey. Apart from the virtual navigation reported below, the images give a real measure of the severe degradation of the sites even on a ten-year scale, a pertinent reminder of the need to undertake relevant preservation actions; some examples will be shown in chapter 6.

In the following, we briefly describe the typologies of documentary data.



142
143
144
145
146
147

Figure 2. (top) Before the abandonment: painting of Gioiosa Guardia (1783 earthquakes) [Mollica, 2003] and drawing of Noto (1693 earthquakes) [Tobriner, 1982]; (bottom) Santa Margherita, the Palace of the Princes Filangeri di Cutò before and after the 1968 earthquakes (courtesy of R. Taiani), and today after restoration.

4.1 HISTORICAL INVESTIGATIONS

In general, the historical analysis is aimed at (i) reconstructing the history and evolution of the settlements, (ii) making an analysis of the process leading to the abandonment in relation to the social context, (iii) searching for elements of building vulnerability in the concerned territory and,

151

152 last but not least, (iv) recovering memories and traditions linked to the traumatic events and looking
153 for their positive meaning (life goes on, people find ways to cope with uncertainty, etc.).

154 Bibliography reporting contemporary accounts on the effects produced by earthquakes is well
155 known to historical seismologists, so we had only to select the sources relevant to a given
156 settlement (see the list reported in the Appendix 1). For the other aspects, it was necessary to
157 consider other kinds of sources and then integrate pieces of useful information to cover the
158 aforementioned aspects.

159 On the whole, for the case studies of Sicily we examined a bibliography totaling more than one
160 hundred sources of different kinds, from local diaries to socio-anthropological and architectural
161 studies, as well as newspapers (for the 1968 earthquakes).

162

163 **4.2 PHOTO AND VIDEO DOCUMENTATION**

164 Since the late 1800s, photography has represented a powerful means of documentation when
165 dealing with seismic disasters. Some images of devastation entered into collective memory,
166 characterizing each earthquakes by different stereotypes; for example, the ones of the 1908 Messina
167 earthquake focus considerably on the human dimension of the disaster [Azzaro et al., 2008].

168 The 1968 *Valle del Belice* case-history, as for other recent earthquakes, is documented by a huge
169 number of photographs coming from books, photographic archives of newspapers – mainly regional
170 such as *l’Ora* and *Giornale di Sicilia* printed in Palermo, or *La Sicilia* in Catania – as well as from
171 private collections. At that time also video shooting was common both by the Italian television and
172 local moviemakers. Therefore, the search sought to document (i) life scenes before and after the
173 abandonment, (ii) damage effects (settlement or single building), (iii) rescue operations and (iv)
174 architectonic and construction features. As a result, we selected some hundred photos and more than
175 1 hour of film.

176 On the other hand, we had to document the present condition of all considered sites. To this end,
177 we made a photographic survey throughout the ghost towns in Sicily by using digital technologies
178 for subsequent multimedia processing. The campaign was carried out during the spring and autumn,
179 when the landscape in Sicily features bright colours without the yellowish hue prevailing in the
180 summer season. In all, we collected more than 3100 photos to be used for the virtual navigation (see
181 section 5.1).

182

183 **4.3 THE MULTIMEDIA TOOL**

184 The last step was to design a multimedia product that linked the navigation throughout the
185 abandoned sites together with the different aspects, both material and immaterial (landscape,
186 construction techniques and architecture, history, folklore and religious beliefs), strictly related to
187 the earthquake. This goal required a highly innovative product at that time, based on the Quick
188 Time™ Virtual Reality [QTVR, see Kitchens, 1998] to visit virtually the deserted settlements and
189 navigate interactively through the different kinds of documents described above [Bitelli et al.,
190 2000b].

191 In short, QTVR allows interactive virtual navigation through a scene (the studied site) starting
192 from a set of nodes (shooting points) [Stern and Lettieri, 2002]. Each node consists of a series of
193 images captured around a single point of rotation (360° or less) provided that: (i) the camera rotates
194 on the axis perpendicular to the one of the lens, (ii) the camera is corrected for parallax, and (iii) the
195 lens produces rectilinear images. Images have been acquired by a digital Nikon camera, in JPEG

196 file format at a resolution of 2560 x 1920 pixels, by using two lenses (28 and 35 mm) and a special
197 tripod for QTVR shooting.

198
199

200 5. RESULTS: THE DVD-ROM

201 In 2003-6, when we were working on the ghost towns in Sicily, the availability of multimedia
202 tools capable of including QTVR navigation and other types of content, with a good resolution and
203 interactively linked, was quite limited. So the choice fell on using the DVD-Rom, which was
204 mounted by the Macromedia Director™ multimedia authoring environment, a platform created for
205 stand-alone multimedia applications. Looking at the resources available on the internet today, this
206 may appear rather impractical since the distribution of a physical support occurs only by hand and
207 upgrades cannot be performed without a new release of the DVD.

208 Keeping in mind the educational strategy at the base of the virtual seismic itineraries, we therefore
209 created a multimedia product through which the user – high school students as well as adults – can
210 navigate through space and time, visit the ghost towns, reconstruct the historical events leading to
211 the abandonment and consider the earthquake as an element of fragility of their own territory. In
212 order to disseminate the DVD as widely as possible, we published both Italian and English versions
213 (Appendix 3).

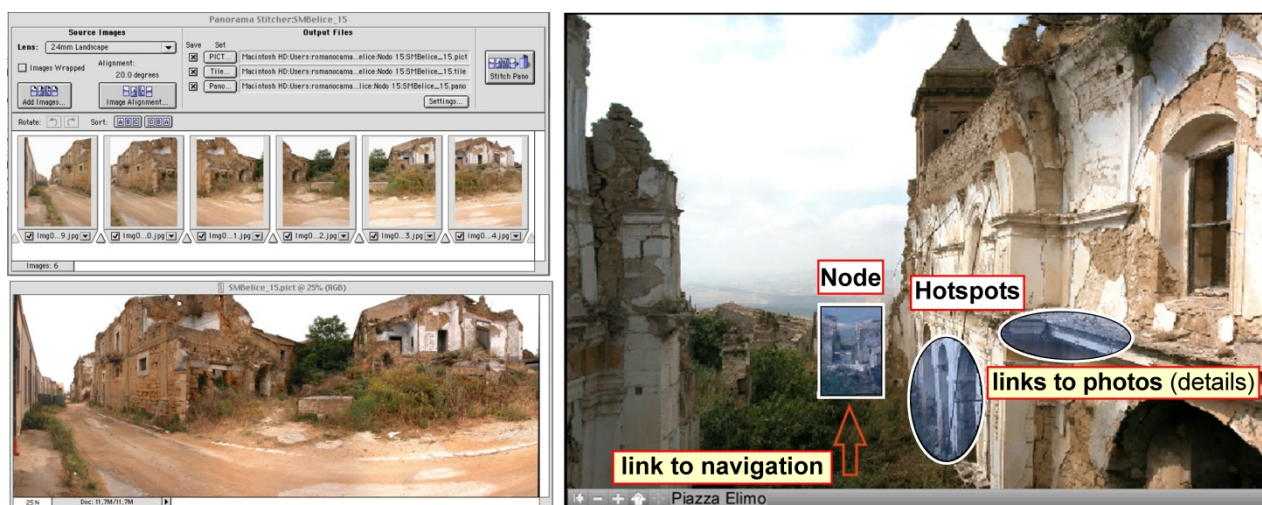
214 In the following, we describe some aspects of the DVD.

215

216 5.1 QTVR IMAGE PROCESSING

217 A preliminary but time-consuming step in preparing the QTVR navigation through the sites was
218 processing the photographic material acquired in the field. Since light conditions were rather
219 different during shooting campaigns, even in a day, the images have been corrected to obtain a
220 uniform colour calibration, contrast and brightness. The corrected images are then stitched together
221 using a specific software, Apple QuickTime VR Authoring Studio™, to create a single QTVR
222 panorama image that is the representation of a 3-D cylinder, virtually without any conical or
223 spherical deformation (Figure 3).

224



225
226

227 **Figure 3.** (left) S. Margherita, example of stitching single images to obtain a QTVR panorama (single node); this
228 panorama image is then converted into a movie by the QuickTime™ platform. (right) Poggioreale, example
229 of QTVR window for interactive navigation throughout the nodes or static images showing details.

230
231
232
233
234
235
236
237
238
239

The next step was mounting the QTVR scenes, which represent a collection of more QTVR panoramas linked together via a set of hotspot areas. In the final QTVR scene, one for each settlement, the user can navigate from panorama to panorama (i.e. the nodes); each scene has an entry node showing the default view when the scene is opened, and it is enriched by links to static images to view architectural details. The QTVR scenes are finally saved as a self-contained file in MOV format, which can be played by the QuickTime™ application compatible with both Macintosh and Windows platforms. For the case studies of Sicily, 146 nodes in all were mounted (Table 2).

Deserted locality	Nodes 360°	Nodes 270°	Nodes 180°	Total nodes	Total shots	Single shots
Val di Noto						
Avola Vecchia	2	1	1	4	60	42
Buscemi	4	1	1	6	92	38
Calatabiano Vecchia	3	3	1	7	113	68
Fenicia Moncada	1			1	20	10
Licodia Eubea	2		1	3	46	6
Noto Antica	4	3	7	14	178	78
Occhiolà	10			10	186	26
Sortino Vecchia	2		2	4	58	68
Spaccaforno	5	1	2	8	115	73
Terravecchia	5		1	6	103	33
Valle del Belice						
Gibellina	6	1	1	8	144	30
Montevago	7	2	2	11	183	44
Poggioreale	11	4	8	23	289	150
Salaparuta	8	1	1	10	184	80
Santa Margherita	6	2	9	17	205	80
S. Maria del bosco	3		1	4	64	76
Val Dèmone						
Gioiosa Guardia	5	2	3	10	167	40
Total	84	21	41	146	2207	942

240
241
242
243
244
245
246
247
248
249
250
251
252
253
254

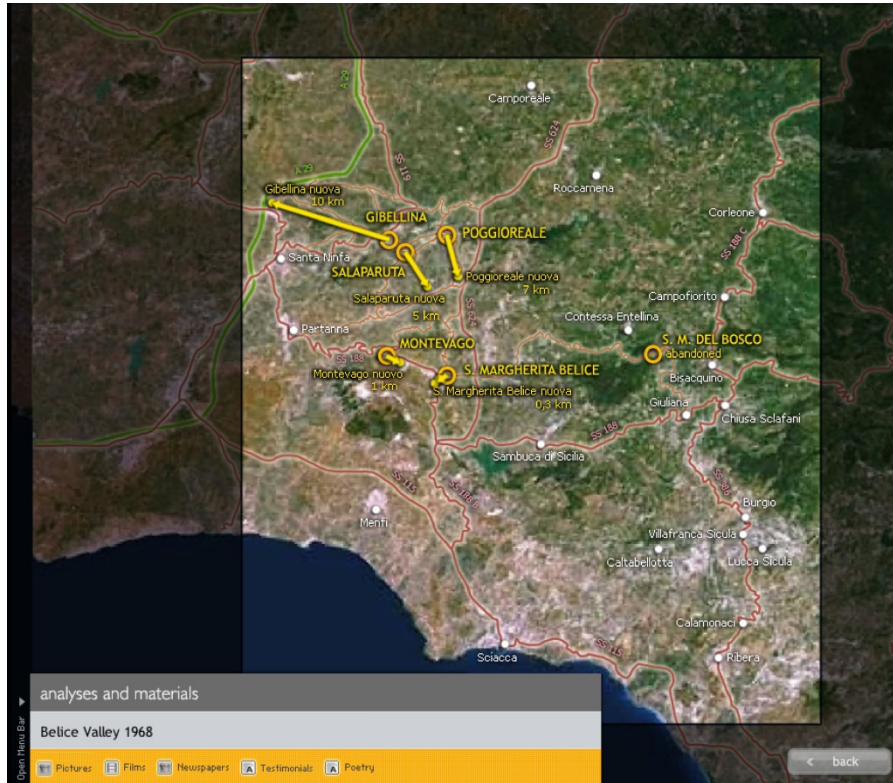
Table 2. Inventory of QTVR panoramas and single images used for the virtual navigation. File size of the nodes ranges from 3.5 to 34 Mb each. The position of the single nodes for each abandoned settlement, is reported in Appendix 2.

5.2 STRUCTURE OF DVD AND NAVIGATION

Navigation is possible through three thematic paths: (i) *Time*, memory retrieved thanks to historical documents, (ii) *Space*, the land seen through pictures, (iii) *Seismicity*, natural causes and their features. Each path presents and links together the DVD contents from a different perspective, highlighting particular features.

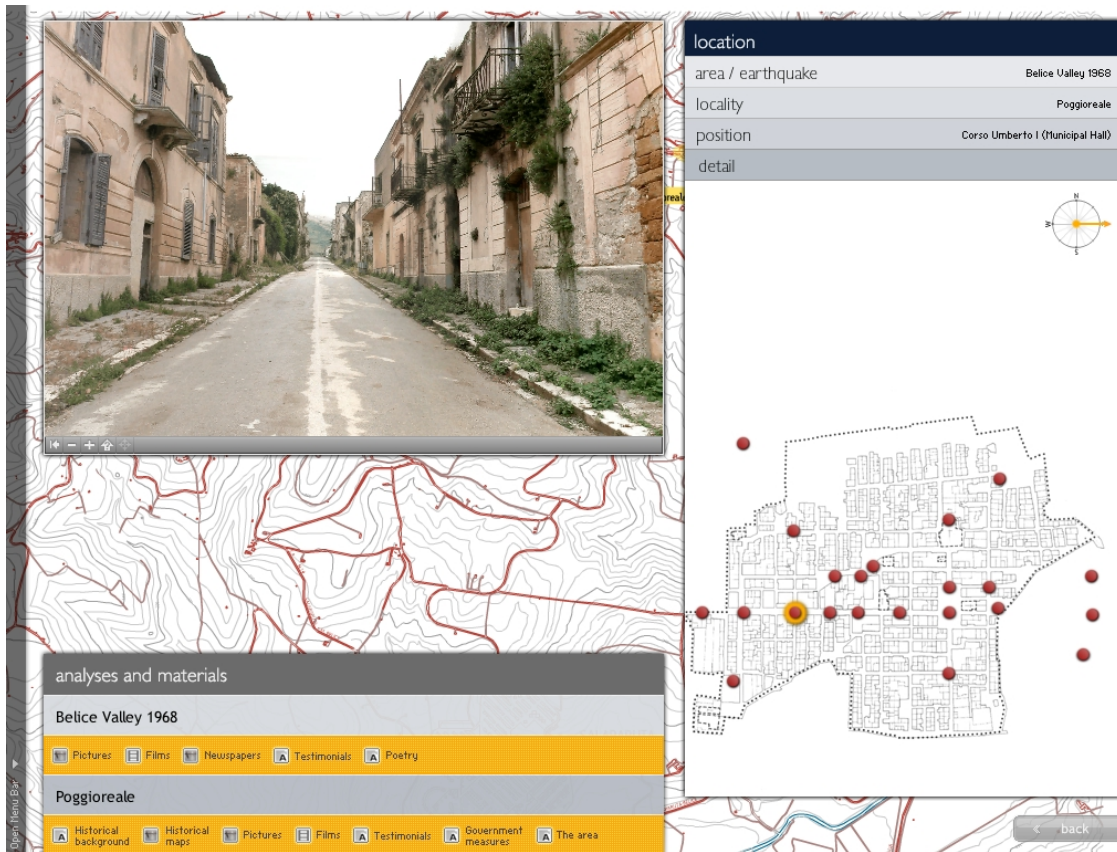
In the section *Time*, we proposed seven movies that narrate brief stories focused on different moments of life with respect to the earthquake event, namely: *The house, stables and hoe; Earthquake; Thinking about the living; 20 years in a shanty; Gibellina, museum-city; Poggioreale, old village nostalgia; Noto Antica, where time has stopped.*

255 In the section *Space*, the virtual journey starts by choosing one of the three macro-areas studied
256 (Figure 4). For each of them, documents are organized in a standard format: historical cartography
257 (city maps before the earthquake); pictures (paintings or photos of the settlements before/after the
258 event), films (for the 1968 event, illustrating destruction and way of living), newspapers,
259 testimonials and poetry (remembering the event).



260
261 **Figure 4.** Access window to the *Valle del Belice* macro-area. When moving the mouse over the name of an abandoned
262 locality, a yellow arrow shows the distance between the old and new settlement.
263

264 At a next level, the user selects the site of interest for the virtual visit. The QTVR window is
265 flanked by an interactive map of the site showing the location of the selected node with the viewing
266 angle (Figure 5). Detailed documentation is available for each site, with a similar standard format as
267 the one of the above level; the additional items are: historical background (features and evolution of
268 the settlement); testimonials (personal experiences and reports during the shock); government
269 measures (rescue organization and reconstruction policies); the area (features of the territory with
270 respect to the seismic hazard).
271



272
273
274
275
276
277

Figure 5. Virtual visit of Poggioreale and access to various features: exploring a site is possible using both the QTVR window (left) and the interactive topographic map (right); the selected node is highlighted in orange, and related information is also shown (on the top).

5.3 SEISMOLOGICAL DATA

279 Lastly, information on earthquakes causing the abandonment of the settlements, is reported in the
280 Seismicity section. Considering the rich bibliography available on the 1693-1783-1968 earthquakes,
281 as well as the technical literature dealing with seismic risk issues in Sicily, we had to simplify the
282 geophysical contents in order to provide only the key elements, enabling the user to gain an
283 awareness of the seismic history of their own territory and the areas most exposed to risk.

284 To this end, we organized the section into three sub-topics: (i) regional seismicity (where and
285 how earthquakes occur) and earthquakes leading to the abandonment of settlements (intensity maps,
286 seismograms, simulations) (Figure 6); (ii) maximum observed intensity and seismic history of any
287 municipality in Sicily; (iii) seismic classification. Each of them is supported by interactive maps
288 and relevant graphs, so users can select the place they live in.

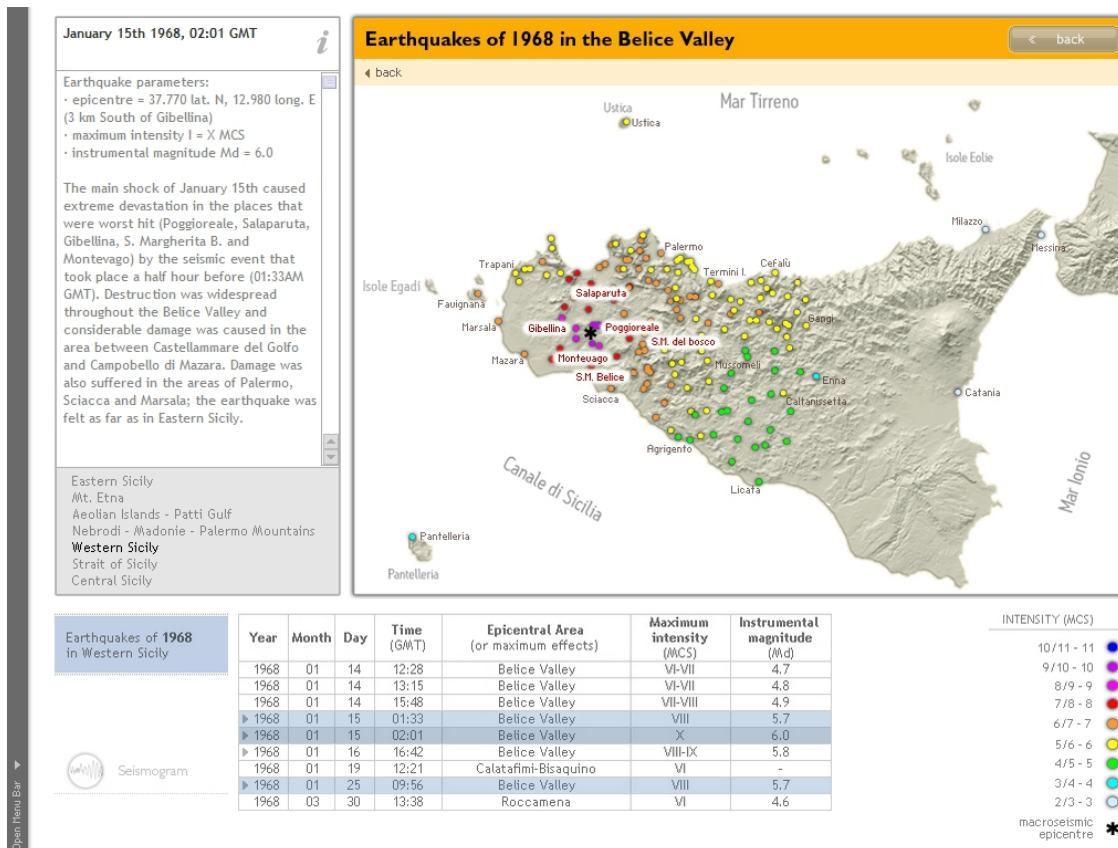


Figure 6. Screenshot of the 1968 seismic sequence. By moving the mouse over the map or clicking on the menu on the left the user can choose an area or an earthquake. The coloured lines on the table below provide a detailed macroseismic map for the specific event; the locations highlighted in red are links to the virtual visit.

6. GHOST TOWNS: A COLLECTIVE HERITAGE TO BE PRESERVED

The archaeological traces of the abandoned settlements throughout Sicily appear today either as fairly substantial ruins or, for some recent cases, as half-destroyed villages. In the *Val di Noto*, the state of preservation of the sites is consistent with the lengthy period elapsed since 1693, overall field evidence being limited and, in a few cases, almost vanished. There is indeed a protection action by the Superintendence of the archaeological heritage, with the institution of zones subject to restrictions and, in the case of the most important sites (Noto Antica, Occhiolà, Terravecchia), there have been systematic excavations as well [Hofer, 1996; Barra Bagnasco, 2006; Racinet and Woimant, 2010]. But there is also the dramatic case of Fenicia Moncada, a site that in the last decades has been obliterated by an almost uncontrolled building development; today no more than a few stones remain, and people now living here unfortunately are not aware of the history of the old town (Figure 7).



306
307
308
309
310
311
312
313
314
315
316
317
318
319

Figure 7. Fenicia Moncada, remains of old buildings in the 1970s. Today, everything has been destroyed by unregulated residential development and buildings.

On the other hand, the present condition of the ghost towns in the *Valle del Belice* is, in some ways, even more worrying, since they are quickly disappearing just 50 years after the event. Apart from Gibellina - which was initially almost completely destroyed by dynamite to prevent people remaining and later transformed into a *plein air* land art sculpture, the renowned *Cretto* - the other deserted settlements show very different degrees of conservation from each other. Salaparuta appears reduced to rubble, and only the convent of the Capuchins and the Holy Mother church were lately restored, but some architectonic details have been lost forever, also owing to thefts perpetrated over time (Figure 8).



320
321

322 **Figure 8.** Salaparuta, degradation process of the Holy Mother church. Some architectonic details, such as the railings,
323 balustrade and entrance steps are now definitively lost.

324
325 At Montevago, preservation is limited to the establishment of a walking route throughout the
326 centre and little else – the house of *Baglio* Ingoglia and a few watering troughs around the village –
327 but the monumental Holy Mother church still appears as a heap of massive stones., Among the
328 ghost towns of the *Valle del Belice*, Santa Margherita undoubtedly represents the best example of
329 recovering historical memory. Its symbolic places, the main square with the Palace of the Princes
330 Filangeri di Cutò (ancestors of Tomasi di Lampedusa, the author of *The Leopard*) and the remains
331 of the Holy Mother church now integrated into the modern structure of the *Museo della memoria*,
332 have been restored (Figure 9); some houses have also been repaired in the old, deserted part of the
333 village.
334



336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351

Figure 9. Santa Margherita, the symbolic places of memory: (top) the ruins of the Holy Mother church (left, in 2003) have been integrated within the structure of the *Museo della memoria* (right, in 2019), thus being preserved from deterioration due to weathering. (bottom) the Palace of the Princes Filangeri di Cutò, now a venue of the literary park dedicated to the writer Tomasi di Lampedusa.

Poggioreale survived the 1968 earthquakes to keep its urban layout almost intact – most buildings were still standing – and a visit to the village is really striking. In spite of this, no preservation action has been undertaken over the years so that it now represents the worst case of conservation of cultural heritage in the *Valle del Belice*. Especially over the past decade, the entire structure of the village has been deteriorating rapidly; buildings have collapsed and the remains having any architectonic relevance or significance for the local community are close to disappearing if urgent action is not undertaken (Figure 10). Moreover, in recent years the old settlement of Poggioreale is being used for international training of the Civil Protection, but this activity is having a negative impact on the conservation of the village due to the extreme fragility of the ruins.



352
353
354
355
356
357

Figure 10. Poggioreale, the symbolic places disappearing: (top) the bell tower of the Holy Mother church in the early 1900s (courtesy of G. Coco), in 2003 and finally as it appears today, after the collapse occurring in 2009. (bottom) the degradation of the small theatre along the main street, is apparent in just 15 years.

358 Lastly, a similar misfortune struck the Benedictine abbey of Santa Maria del bosco, 15 km east
359 of the other abandoned settlements of the *Valle del Belice*. This place, little known to most people,
360 is a magnificent pearl of great artistic and cultural value nestled in the woods of Mount Genuardo:
361 the church contained majolicas by Luca della Robbia, while the monastery hosted the young
362 Torquato Tasso before he wrote the poem *Jerusalem Delivered*. The monastery became privately
363 owned after the unification of Italy in 1861; after the 1968 earthquakes, it was restored and more
364 recently is being used as a resort. But, conversely, the monumental church is in a very bad condition
365 since no conservation work has been undertaken: the building appears half- collapsed so that the
366 interior is exposed to weathering processes, which are intense at an altitude of 800 m/asl (Figure
367 11).
368



369
370
371 **Figure 11.** Santa Maria del bosco: (top) the abbey in the mid-1900s (courtesy of Mons. F. Ferina) and the present-day
372 condition. Note the dramatic difference between the part of monastery entirely restored (privately owned,
373 now it is a resort) while the church is collapsing. (bottom) the inner of the church in the mid-1900s, now the
374 remains of apse, nave and ornaments are without any protection, exposed to very fast degradation processes.
375

376 377 7. CONCLUSIONS

378 The theme of the ghost towns is a complete educational and cultural tool to explore and interpret
379 the traces left by destructive earthquakes in their own territory. This original methodological
380 approach may be a key step in educational strategies to develop a real culture of preparedness and
381 awareness on the issues of seismic risk; rediscovering abandoned settlements also provides a new
382 perspective on the role of the cultural heritage and the significance of historical memory. A further
383 aspect that should be mentioned is the importance of the abandoned towns for knowledge of the
384 degradation process of the structures. This is a key issue in archaeoseismology, and these ruins offer
385 the possibility of a systematic documentation of the degradation processes.

386 The process of abandoning and resettling a village, whether or not due to earthquakes or other
387 causes, was rather frequent in Italy until the 1970s, with the 1968 *Valle del Belice* case-history
388 probably representing the last most significant example. Thereafter, this choice was no longer
389 proposed as a standard model for post-earthquake reconstruction, being limited to some extreme
390 cases such as Friuli in 1976 and Irpinia in 1980 [Guidoboni and Valensise, 2011]. Following the
391 2017 Central Italy earthquakes, the debate today continues on whether the village of Pescara del
392 Tronto should be reconstructed in the same place notwithstanding that the site is entirely located on
393 a landslide (Rossi et al., 2019).

394 The lessons learned by the analysis of case-histories in Sicily highlight that the ghost towns are
395 not adequately protected as a collective heritage, which deserves to be exploited and promoted in
396 the framework of a network of outdoor museums. While the scars, moral and material, of the
397 abandonment are still visible around the *Valle del Belice*, where the earthquake wreaked destruction
398 fifty years ago, in the wealthy *Val di Noto* on the other hand, the seismic catastrophe of 1693
399 provided an opportunity for social and cultural rebirth, with the Sicilian Late Baroque as a unifying
400 factor in the reconstruction [Dufour and Raymond, 1994]; the case-history of Noto is the most
401 representative [Tobriner, 1982]. Now the area of south-eastern Sicily is in the UNESCO world
402 heritage list (<https://whc.unesco.org/en/list/1024>), and continues to attract a huge number of
403 visitors. However, in recent years there has been a new trend of academic, multi-disciplinary
404 training throughout the areas struck by earthquakes in Italy, and also the ghost towns of the *Valle*
405 *del Belice* are being rediscovered through a “naturalistic” walking journey that links history,
406 anthropology and land planning (<https://www.laboratoriodelcammino.com/sicilia-coast-to-coast>).

407 Finally, the DVD devoted to the Sicilian ghost towns [Azzaro et al., 2006] represents a
408 prototype multimedia tool whose methodological approach is still highly valid. Today, multimedia
409 technology is more advanced and web-oriented, leading to the development of more dynamic on-
410 line platforms, allowing introducing new towns and villages or materials. In this direction, for
411 example, also the possibilities offered by the increasingly high-resolution coverage by Google
412 Street View could be applied to explore the ghost towns, to document the effects of current
413 earthquakes [e.g. Hinzen, 2013] as well as to follow the changes in recent earthquake hit areas.
414 Basing on new technology, the next stage of the virtual itineraries through the seismic history of
415 Italy could be Calabria [Azzaro, 2012].

416

417

418 **ACKNOWLEDGMENTS**

419 The authors are grateful to R. Camassi (INGV, Dept. of Bologna), who introduced us to the
420 fascinating theme of the ghost towns in Italy and to the immersive QTVR navigation. We also wish
421 to thank K.G. Hinzen and an anonymous referee for their useful comments, and express sincere
422 gratitude to those for providing materials from their own personal collections: V. Belfiore (Noto),
423 G. Bruno (Sortino), V. Bruno (Belpasso), M. Cardoni (Rome), G. Coco (Poggioreale), P. Magro
424 (Avola), M. Rametta (Montevago), R. Taiani (Santa Margherita) and G. Zuccaro (Catania). Special
425 thanks go to G. Tomarchio, who originally selected videos from the Italian television archives (now
426 available on <http://www.teche.rai.it/>). Without all of these valuable contributions, the DVD would
427 not have been really complete. Thanks to S. Conway for revising this text.

428

429

430 **REFERENCES**

431

432 Azzaro, R., M. Cascone, R. Camassi, A. Amantia, F. Gugliemino, S. Mangiagli and L. Peruzza,
433 (2006). Earthquakes and ghost towns in Sicily: a journey through places of memory. INGV,
434 Project Edurisk (Itineraries for the reduction of seismic risk), DVD-Rom, available also in
435 Italian version.

436 Azzaro, R., C. Piccione, and G. Valensise (2008). Terremoto Calabro Messinese, 1908/2008.
437 Alinari-24 Ore, Firenze, 175 pp., ISBN 978-88-6302-020-5.

438 Azzaro, R. (2012). Terremoti e città fantasma: un percorso attraverso le tracce degli eventi
439 distruttivi del passato, *Miscellanea INGV*, 13, 24-28.

440 Barra Bagnasco, M. (2006). Da Terravecchia di Grammichele a Occhiola. Archeologia di un
441 insediamento della Sicilia centro orientale: campagne di scavo 2000-2001. Edizioni dell'Orso,
442 Collana Mnème. Documenti, culture, storia del Mediterraneo e dell'Oriente Antico, 512 pp.,
443 ISBN 978-88-7694-908-9

444 Bitelli, G., R. Camassi, M.A. Tini and L. Vittuari (2000a). From the photographic survey to the
445 virtual reality movies and web integration for the study of an archaeological site, *Proceedings*
446 *of the 2nd international congress on "Science and technology for the safeguard of cultural*
447 *heritage in the Mediterranean basin"*, Paris, 5-9 July 1999, Elsevier, 1,149-151.

448 Bitelli, G., R. Camassi, M.A. Tini and L. Vittuari (2000b). Una realizzazione in realtà virtuale per la
449 consultazione e l'esplorazione in remoto di un sito archeologico: la casa VIII in Bakchias.
450 *Papyrologica Lupiensia*, 8, 91-101.

451 Branca, S., R. Azzaro, E. De Beni, D. Chester and A. Duncan (2015). Impacts of 1669 eruption and
452 the 1693 earthquakes on the Etna Region, (Eastern Sicily, Italy): an example of recovery and
453 response of a small area to extreme events. *J. Volc. Geotherm. Res.*, 303, 25-40.

454 Camassi, R. (2004). I paesi abbandonati. *Parametro, Rivista internazionale di architettura e*
455 *urbanistica*, 251,50-55.

456 Camassi, R., R. Azzaro, V. Castelli, F. La Longa, V. Pessina and L. Peruzza (2005). "Knowledge
457 and practice". Educational activities for reduction of earthquake impact: the EDURISK project,
458 In: *Proc. Int. Conf. on the 250th Anniversary of the 1755 Lisbon Earthquake*, 1-4 November
459 2005, Lisbon (Portugal), 100-104.

460 Dufour, L. and H. Raymond (1994). 1693 Val di Noto: la rinascita dopo il disastro, Sanfilippo Ed.,
461 Catania, 316 pp.

462 Gangemi, G. and R. La Franca (1979). Centri storici di Sicilia. *Inventario di protezione dei sistemi*
463 *urbani delle provincie di Trapani, Agrigento, Caltanissetta, Enna, Vittorietti Ed., Palermo*, 1, 98
464 pp.

465 Guidoboni, E. and G. Valensise, (2011). Il peso economico e sociale dei disastri sismici in Italia
466 negli ultimi 150 anni, 1861-2011. *Bonomia University Press, Bologna*, 550 pp., ISBN 978-88-
467 7395-683-9.

468 Hinzen, K. G. (2013). Support of macroseismic documentation by data from Google Street View.
469 *Seismological Research Letters*, 84 (6), 982-990, doi:10.1785/0220130019.

470 Hofer, P. (1996). *Idealstadt und Stadtraum im sizilianischen 18. Jahrhundert*. GTA-Verlag, ETH
471 Zurich, 171 pp., ISBN 978-3-85676-049-6.

- 472 Kitchens, S. (1998). *The QuickTime™ VR Book. Creating immersive imaging on your desktop*,
473 Peachpit Press, New York, , 296 pp., ISBN-13: 978-0201696844.
- 474 Klapisch-Zuber, C. (1973). *Villaggi abbandonati e emigrazioni interne. Storia d'Italia, V, I*
475 *documenti*, pp. 309-364.
- 476 Mollica, M. (2003). *Gioiosa Marea. Dal Monte di Guardia a Ciappe di Tono e San Giorgio. A.*
477 *Siciliano Ed., Messina, 303 pp.*
- 478 Pessina, V. and R. Camassi (2012). *EDURISK 2002 – 2011: 10 anni di progetti di educazione al*
479 *rischio, Miscellanea INGV, 13, 77 pp.*
- 480 Principe, I. (2001). *Città nuove in Calabria nel tardo Settecento. Gangemi Editore, Roma, 410 pp.*
- 481 Racinet, P. and G.P. Woimant (2010). *Le site archéologique médiéval et moderne de Terravecchia*
482 *(Sicile, Italie), Archéologie médiévale, 40, 49-88.*
- 483 Rossi, A., A. Tertulliani, R. Azzaro, L. Graziani, A. Rovida, A. Maramai, V. Pessina, S.
484 Hailemikael, G. Buffarini, F. Bernardini, R. Camassi, S. Del Mese, E. Ercolani, A. Fodarella,
485 M. Locati, G. Martini, A. Paciello, S. Paolini, L. Arcoraci, C. Castellano, V. Verrubbi and M.
486 Stucchi (2019). *The 2016-2017 earthquake sequence in Central Italy: macroseismic survey and*
487 *damage scenario through the EMS-98 intensity assessment. Bull. Earth. Eng., 25 pp.,*
488 <https://doi.org/10.1007/s10518-019-00556-w>.
- 489 Rovida, A., M. Locati, R. Camassi, B. Lolli and P. Gasperini (2016). *CPTI15, the 2015 version of*
490 *the Parametric Catalogue of Italian Earthquakes. INGV, doi: [http://doi.org/10.6092/INGV.IT-](http://doi.org/10.6092/INGV.IT-CPTI15)*
491 *CPTI15. <http://emidius.mi.ingv.it/CPTI15-DBMI15/>.*
- 492 Stern, J. and R. Lettieri (2002). *QuickTime 6 for Macintosh and Windows. Visual quickstart guide,*
493 *Peachpit Press, New York, 3rd edition, 520 pp., ISBN-13: 978-0321127280.*
- 494 Teti, V. (2004). *Il senso dei luoghi. Paesi abbandonati di Calabria. Ed. Donzelli, Roma, 569 pp.*
- 495 Tobriner, S. (1982). *The genesis of Noto: an Eighteenth-Century Sicilian city. University of*
496 *California Press, Studies in Architecture, 21, 252 pp.*

497

498 Appendix 1

499 List of references used for the DVD.

500

501 Appendix 2

502 Position of the single QTVR nodes inside the documented settlements.

503

504 Appendix 3

505 Links to download the DVD files (English and Italian versions).