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Historical damage pattern and differential seismic effects in a town with ground cavities: A case study from Southern Italy

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Abstract

This paper presents the results of a study focused on the analysis of differential seismic effects on a town characterized by the presence of ground cavities. The event analysed is the 1930 Irpinia earthquake (Io = X MCS; Me = 6.7), whereas the site investigated is Rionero in Vulture (Basilicata, Southern Italy). This town is built, as several historical centres over the world, on man-made ground cavities going back to the past centuries. Due to the high-quality of available historical information regarding the 1930 seismic event, the analysed town represents an important case-study both to improve the reconstruction methodology of the damage 'scenario' and to test the role that ground cavities play on seismic damage in a site with high seismicity. To this purpose, we examined about 1400 unpublished technical reports. The information, drawn from written sources, was integrated with *in situ* surveys. Furthermore, we made a comparison with seismic effects which were recorded in some Italian localities having ground cavities.

The results of this research can provide useful information for microzonation analysis and decision making for localities where seismic, territorial and anthropic features are similar to Rionero in Vulture. The paper is divided into four parts: the first one analyses the geological features of the region and the town; the second part describes the historical seismicity of the site; the third part deals with the methodological approach in order to reconstruct the building damage; finally, the fourth part is focused on the analysis of the damage pattern with appraisals of the causes of differential effects.

Keywords: Historical seismology; Archival sources; Damage scenario; Southern Italy; Rionero in Vulture

1. Introduction

Macroseismology is a branch of seismology that collects and evaluates the effects of seismic events on people, buildings and nature. One can apply macroseismic studies to all earthquakes: present, recent and historical ones. The latter pertain to seismic events in pre-instrumental historical times where written sources are available and, therefore, the data analysis is managed by historical seismology. However, the method of historical seismology has also applied in an extensive way to the recent or instrumental earthquakes until around the end of World War II (Ishibashi, 2004). The methodological approach to the present (that is coeval to the researcher) and recent-historical earthquakes is significantly different. The former require extensive experience, which derives from on-field surveys; on the contrary, the latter need in-depth, correlated and time-

Abbreviations: ASCR, Archivio Storico Comunale di Rionero; ASPz, Archivio di Stato di Potenza.

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contextual analyses of the documentary sources. From a rigorous methodological point of view, it is necessary to reconstruct the whole procedure of the collection and evaluation of damage data. The researcher must re-live the event from the viewpoint of a coeval eyewitness as well as analyse the documentary sources concerning the cultural and ideological background at the time of the earthquake. Moreover, as regards recent earthquakes, it is often necessary to set up an analysis of the information suitable for the abundance and the high degree of detail of the data.

The paper deals with a detailed reconstruction of the damage 'scenario' of the earthquake on 23 July 1930 in Rionero in Vulture downtown (Basilicata, Southern Italy) (Fig. 1). This part of the town is characterised by hundreds of man-made cavities which were dug in historical times, as common in the Basilicata Region where several towns and villages show hundreds of cavities in the downtown area (*e.g.*: Gizzi, 2004). Both natural cavities (mainly of karst origin) and man-made ones (frequently dug in volcanic deposits) are present in downtown area of many cities over the world such as Mexico City (Tejero et al., 2002), Nottingham (Waltham and Swift, 2004), New Orléans (Thierry et al., 2005).

In Italy, we could mention Rome (*e.g.*: Crescenzi et al., 1995), Naples (*e.g.*: Evangelista, 1991), Palermo (*e.g.*:Todaro, 1986), Catania (*e.g.*:Bonaccorso and Lo Giudice, 2002), Orvieto (*e.g.*:Barla and Soccodato, 2000). Rionero in Vulture, a site with high seismicity, can represent an important case-study to test the role played from ground cavities on seismic damage. For this reason, after the reconstruction of the damage pattern, we performed an analysis of the causes of damage.

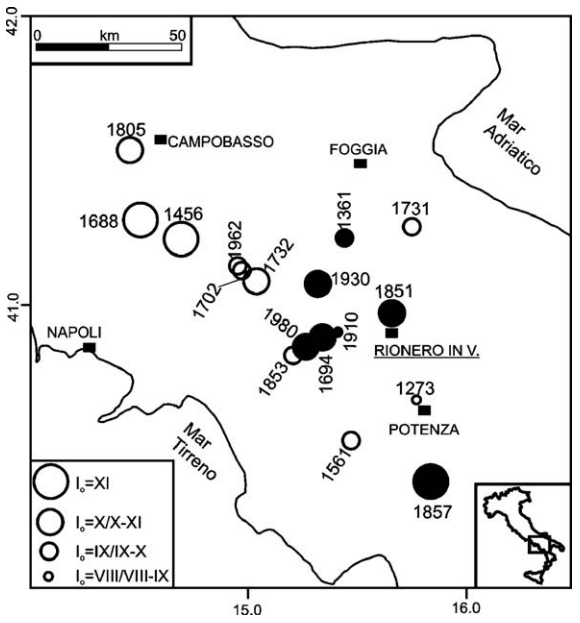

Fig. 1. Location of the study area and epicentral distribution of largest historical earthquakes "recorded" in the Southern Apennines (data are drawn from Boschi et al., 2000). Black circles show earthquakes felt with higher intensity at the site of Rionero in Vulture (see also Fig. 4).

Further, we considered the role that the ground cavities played in some of the aforementioned Italian localities. The research was made possible thanks to the analyses of the coeval technical primary sources, which guarantee a good quality of information (Guidoboni, 2000). In particular, the original consulted sources are, in order of importance: unpublished technical–administrative dossiers drawn up after field surveys by engineers of the Special Office of Civil Engineers (afterwards SOCEM), unpublished geological reports, prefecture documentation, archives of the local administration, deeds of institutions.

On the whole, the research supplies useful information for microzonation analysis and decision making for localities where seismic, territorial and human features are similar to Rionero in Vulture.

Several Italian historical cities have already been the object of analyses of past earthquakes 'scenarios': Rimini (Ferrari, 1986); Roma (Molin and Guidoboni, 1989; Rovelli et al., 1995; Tertulliani and Riguzzi, 1995); Syracusa (Boschi et al., 1993, 1995); Florence (Guidoboni and Ferrari, 1995; Molin and Paciello, 1999); Isernia (Esposito et al., 1995); Senigallia (Favali et al., 1995); Padova (Guidoboni et al., 1997); Catania (Azzaro et al., 1999; Faccioli and Pessina, 2000; Boschi and Guidoboni, 2001); Palermo (Guidoboni and Mariotti, 1999; Guidoboni et al., 2003); Nicolosi (Barbano et al., 2001); Bologna (Boschi and Guidoboni, 2003); Melfi (Gizzi and Masini, 2004). However, these works are mainly addressed to gather urban seismic effects and not the causes of damage.

2. Geological outline of the Southern Apennines and Rionero in Vulture

Rionero is a town of 13,500 inhabitants, which is situated in the northern part of Basilicata, close to the extinct Vulture volcano, in the Southern Apennines.

The Southern Apennines are a Neogene fold and thrust belt that is made up of a buried carbonate duplex system tectonically overlain by NE verging thrust sheets (*e.g.*: Mostardini and Merlini, 1986; Patacca and Scandone, 1989; Lentini et al., 1996). These ones consist of Mesozoic–Paleogene sediments. They were laid in platform and basin paleogeographic domains