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25-27 June 2018
Possidi, Greece

ON THE OCCASION OF THE 40TH ANNIVERSARY OF THE M 6.5 THESSALONIKI EARTHQUAKE.
COVER: SURFACE RUPTURE AT STIVOS VILLAGE
BACKCOVER: SURFACE RUPTURE AND ASSOCIATED DAMAGE AT STIVOS VILLAGE
(PHOTO CREDIT: GEORGE SYRIDES)

Proceedings of the 9th International INQUA Workshop on Paleoseismology, Active Tectonics and Archeoseismology

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Macroseismic intensities assessment of the August 21, 2017 Casamicciola earthquake at the Ischia volcanic Island (southern Italy)

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Abstract: *On August 21, 2017 at 20:57 (Local Time) a very shallow earthquake (ca 1.2 km depth) of M_d=4.0 hit the Ischia island (Southern Italy) heavily damaging the Casamicciola Terme village and also the Lacco Ameno village, causing two fatalities and about 40 people injured. Soon after the mainshock we surveyed the area and collect macroseismic data in order to assess the MCS intensity and the ESI-07 intensity values. We assigned the maximum intensity value I= VIII MCS at Casamicciola Terme on the basis of the damage to buildings and we assessed the epicentral intensity value I= VII ESI-07 on the basis of primary and secondary coseismic ground effects. We point out that the Casamicciola volcano-tectonic earthquake (M_d=4), has had catastrophic consequences on local communities, therefore this study can provide relevant implications for seismic hazard evaluation and land use planning in the Ischia island.*

Keywords*: Volcano-tectonic earthquake, Intensity values, Ischia island, ESI-07scale*

INTRODUCTION

The Ischia Island (Southern Italy) is located at the northwestern side of the Gulf of Naples inside of the Campanian volcanic province that also includes the Campi Flegrei volcanic field. This island is known all over the world for its tourist peculiarities, and since ancient times for its healing thermal waters.

Ischia is the emerged portion of a volcanic complex, active since at least 150 ka. (Vezzoli, 1988). The most impacting event in the island geological history is the caldera forming eruption of the Green Tuff of the Mt. Epomeo occurred 55 ka, that caused the collapse of the island central sector, followed by the resurgence of the Mt. Epomeo block, starting from 30 ka. From 10 ka, the eruptions mainly located in the eastern part of the island; the last effusive Arso eruption occurred in 1302 (Orsi et al., 1991; de Vita et al., 2010).

The uplift of the Mt. Epomeo resurgent block was asymmetric, with maximum displacement on the N flank, controlled by E-W normal faults system well described in the literature (Figure 1) (Vezzoli, 1988; Tibaldi & Vezzoli, 1998; Acocella & Funiciello, 1999; Carlino et al., 2006; de Vita et al., 2010; Nappi et al., 2010). The main faults system bording the Mt. Epomeo consists of NW-SE to N-S striking faults in the western sector and of NE-SW to E-W faults in its northern sector. In the eastern sector of the island, N-S and NE-SW striking fractures and faults control the location of the vents.

The northern flank of Mt. Epomeo is considered the most tectonically active sector, with an estimated total uplift of 920-970 m, inferred from the present height of uplifted marine deposits, eustatic variations and basin subsidence (Barra et al., 1992). The island is also characterized by several strong historical earthquakes (Alessio et al., 1986; Cubellis & Luongo, 1998, Esposito et al., 2006) concentrated mainly in the northern sector of the island, in the same epicentral area of the August 21, 2017 earthquake.

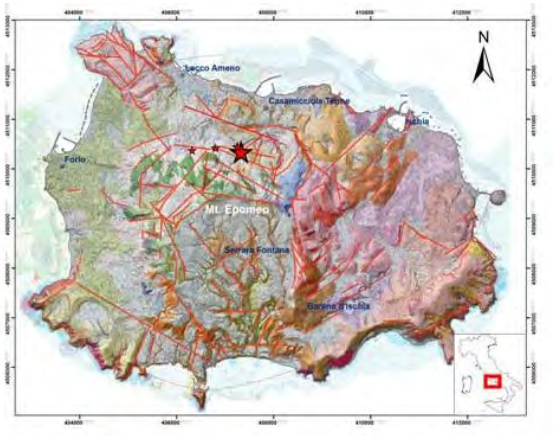

Figure 1: Faults (in red) are from Acocella and Funiciello (1999), de Vita et al. (2010), Vezzoli (1988), Tibaldi & Vezzoli (1998) and geomorphological lineaments from Nappi et al. (2010). The base map is Carta Geologica dell'Isola d'Ischia della Regione Campania in scala 1:10.000, Foglio 464, 2011. The greatest red star is the 21 August 2017 main shock with the main aftershocks.

THE AUGUST 21, 2017 CASAMICCIOLA EARTHQUAKE

On August 21, 2017 at 20:57 (local time) a volcano-tectonic earthquake of M_d =4.0 (Lat. 40.74°, Long 13.90°), with shallow depth (1.2 km, de Novellis et al., 2018), hit the Ischia island heavily damaging the Casamicciola Terme village, the neighboring localities, causing two fatalities and about 40 people injured (Figure 2).

Figure 2: Houses collapsed and heavily damaged by the 21 August 2017 earthquake in the hilly historical centre of Casamicciola Terme (Ischia island). Photos by S. Porfido.

This seismic event was felt throughout the island with extremely different intensities $8<I_{EMS}<3$ (Azzaro et al., 2017). The earthquake was also felt in the nearby island of Procida and in some localities on the coast of the Gulf of Pozzuoli with I≤4 MCS (Figure 3).

Figure 3: The MCS intensity distribution in the Ischia island and surrounding areas (http://www.haisentitoilterremoto.it/).

It is important to underline that although the island is characterized by high tourist flow, the most common building typology, spread throughout the island, consists of buildings in tufa stone with wooden or steel floor built between the 19th and 20th century. The earthquake caused a few total collapses and some partial collapses, widespread cross and horizontal lesions, which determined in some cases the total inability of the houses. The quake caused serious damage in a limited area of a few km^2: the Casamicciola Terme village with the maximum intensity of VIII MCS at Piazza Maio (the hilly side of the Casamicciola Terme village) and the Fango district (Lacco Ameno village) with the VII-VIII MCS.

Soon after the mainshock we surveyed the epicentral area in order to collect the coseismic ground effects. We mapped more than 100 geological field observations according the standard procedures of EMERGEO W.G. of INGV (http://emergeo.ingv.it/; Nappi et al., 2017; Nappi et al., 2018).

FIELD SURVEY

Although the 2017 Casamicciola earthquake was a moderate size volcano-tectonic event, we observed several ground effects both primary (surface ruptures and permanent displacement caused directly by the seismogenic source), and secondary effects (landslides, hydrological variations etc.) sensu Keller & Pinter (2002) and Michetti et al. (2007).

The most important type of ground effects collected during the field survey, are: ruptures, fractures, landslides, variations in fumarolic activity and dry wall collapses (Figure 4).

Figure 4: Coseismic surface effects: a) and b) surface rupture in Fango (Lacco Ameno); c) surface rupture in via Montecito (Casamicciola); d) e) landslides in volcanoclastic deposits in Casamicciola.

Generally, the whole investigated area showed different fractures on both manufactures and ground, on road and on ground cover, with direction from WNW-ESE to E-W and WSW-ENE (Figure 1), and lengths up to some tens of meters. In addition, some fractures in the soil had 3 cm wide openings, and in some cases a vertical component of appreciable displacement with lowering of the ground Northward.

Widespread sliding phenomena of drywalls, that are locally known as “parracine”, built mainly with green tuff and also with lava materials, were also observed, with a general direction of movement from south to north, as well as modest gravitational phenomena such as small size collapses of several m^3, and small landslides in volcanoclastic deposits, along the northern slope of Mt.

Epomeo (Nappi et al., 2018). Moreover, an increase of steam emission in the Montecito fumaroles was observed soon after the 21 August seismic event, as witnessed and reported by the local inhabitants.

HISTORICAL SEISMICITY OF THE ISCHIA ISLAND

The Ischia island was characterized by strong seismic events in historical time (Mercalli, 1884; Johnston-Lavis, 1885; Cubellis & Luongo, 2018). The seismicity observed in the island is strongly connected to the volcano-tectonic dynamics of the island itself; the earthquake epicenters are located mostly in the northern zone stretching E-W from Casamicciola to Lacco Ameno (North of the Mt. Epomeo), with usually shallow hypocenters (Alessio et al., 1996; Nappi et al., 2018). The observed MCS intensity values range between VII and XI degree, with rapid decrease of intensities versus the distance. The most important historical seismic events that struck the island occurred in the XIX century as the well-known destructive earthquakes of March 4, 1881 with I=IX MCS and the July 28, 1883 with Imax =XI MCS. Both of these strong earthquakes were located in the hilly area of the Casamicciola Terme village and almost completely destroyed it and the surrounding area. The 1881 event caused about 120 casualties and 140 injured, whereas the 1883 earthquake caused 2,300 fatalities and several environmental effects (Alessio et al., 1996; Cubellis & Luongo, 1998; Del Prete & Mele, 1999; Violante et al., 2003; Luongo et al., 2006; Carlino et al., 2010).

On 1762, 1767, 1796, and 1828 other strong earthquakes, with VII≤I_{MCS}≤IX, occurred in the island and caused many victims and damages to the villages built on the northern sector of the Mt. Epomeo. Several landslides (rockfalls and debris flows) detached from the northern flank of Mt. Epomeo, fractures and hydrological changes were also observed, mainly concentrated along the major fault zones, in the northern sectors of the island, which appear as the most disaster prone areas.

DISCUSSION AND CONCLUSIONS

The Casamicciola Terme village was heavily hit by strong earthquakes since historical times, the most important occurred in 1762, 1796, 1828, 1881, 1883, which allowed to recognize a seismogenic area along the northern slope of the Mt. Epomeo resurgent block (Alessio et al., 1996). These strong earthquakes are comparable with the August 21, 2017 seismic event, both for the epicentral zone, besides the macroseismic and environmental effects.

The prompt macroseismic observations of the level of damage distribution to the buildings, allowed us to assess the preliminary epicentral Intensity I=VIII MCS to Casamicciola Terme (hilly area) and I=VII-VIII MCS to Fango (Lacco Ameno). The pattern of primary coseismic ground effects is represented over all by 62% of ruptures and 17% of fractures; the secondary coseismic effects consisted in 14% of drywall collapses; 6% of landslides phenomena; 5% of steam variations in Montecito fumaroles (Figure 5). According to Nappi et al. (2018) the distribution of coseismic effects allowed us to hypothesize the 2 km end to end rupture as primary surface normal faulting, N dipping, of the 21 August 2017, volcano-tectonic seismic event.

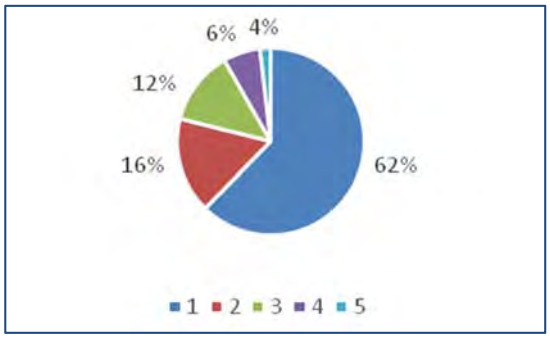

Figure 5: Ground effects induced by the August 21, 2017 Casamicciola earthquake: 62% ruptures (blue); 16% fractures (red); 12% collapse of drywall (green); 6% landslides phenomena (purple); 4% steam variations in Montecito fumaroles (light blue).

Considering the distribution of the primary and secondary coseismic geological data we have assessed the preliminary ESI-07 epicentral intensity; in particular, we have assigned the VII degree of ESI-07 scale by taking into account the total length of the fault segment, ca. 2 km, and the maximum displacement observed, ca. 2-3 cm, as well as the area affected by others secondary coseismic effects, which is only of a few km^2.

In conclusion, , our macroseismic survey pointing out the damaging level and sesimoinduced effects could be used for the reinterpretation of historical earthquakes, and provides new data for understanding the surface faulting mechanism due to a moderate earthquake (M=4.0), for the first time in the Ischia island volcano-tectonic contest.

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