ISSN 2039-6651
anno 2019 numero 48



MISCELLANEA INGV

Photographic collection of the coseismic geological effects originated by the 26th December 2018 Etna (Sicily) earthquake

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

48



Direttore Responsabile
Valeria DE PAOLA

Editorial Board
Luigi CUCCI - Editor in Chief (luigi.cucci@ingv.it)
Raffaele AZZARO (raffaele.azzaro@ingv.it)
Christian BIGNAMI (christian.bignami@ingv.it)
Mario CASTELLANO (mario.castellano@ingv.it)
Viviana CASTELLI (viviana.castelli@ingv.it)
Rosa Anna CORSARO (rosanna.corsaro@ingv.it)
Domenico DI MAURO (domenico.dimauro@ingv.it)
Mauro DI VITO (mauro.divito@ingv.it)
Marcello LIOTTA (marcello.liotta@ingv.it)
Mario MATTIA (mario.mattia@ingv.it)
Milena MORETTI (milena.moretti@ingv.it)
Nicola PAGLIUCA (nicola.pagliuca@ingv.it)
Umberto SCIACCA (umberto.sciacca@ingv.it)
Alessandro SETTIMI (alessandro.settimi1@istruzione.it)
Andrea TERTULLIANI (andrea.tertulliani@ingv.it)

Segreteria di Redazione
Francesca DI STEFANO - Referente
Rossella CELI
Barbara ANGIONI

redazionecen@ingv.it

REGISTRAZIONE AL TRIBUNALE DI ROMA N.174 | 2014, 23 LUGLIO

© 2014 INGV Istituto Nazionale di Geofisica e Vulcanologia
Rappresentante legale: Carlo DOGLIONI
Sede: Via di Vigna Murata, 605 | Roma



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

ISSN 2039-6651
anno 2019 numero 48

MISCELLANEA INGV

Photographic collection of the coseismic geological effects originated by the 26th December 2018 Etna (Sicily) earthquake

Emergeo Working Group*

**Luigi Cucci, Salvatore D'Amico, Paolo Marco De Martini, Rosella Nave, Luca Pizzimenti, Raffaele Azzaro, Stefano Branca, Carlo Alberto Brunori, Marco Caciagli, Massimo Cantarero, Francesca Romana Cinti, Riccardo Civico, Emanuela De Beni, Maria Teresa Mariucci, Alfio Messina, Paola Montone, Rosa Nappi, Daniela Pantosti, Stefano Pucci, Tullio Ricci, Alessandra Smedile, Vincenzo Sapia, Gabriele Tarabusi, Roberto Vallone, Alessandra Venuti, Fabio Villani*

INGV | Istituto Nazionale di Geofisica e Vulcanologia



Accepted 4th July 2019 | *Accettato il 4 luglio 2019*

How to cite | *Come citare* Emergeo Working Group, (2019). Photographic collection of the coseismic geological effects originated by the 26th December 2018 Etna (Sicily) earthquake. Misc. INGV, 48: 1-76.

Cover | *In copertina* The imposing volcanic edifice of Mount Etna seen from the area of occurrence of the 2018 earthquake

48

INDEX

Introduction	**7**
Gallery	**9**
Acknowledgements	**73**
References	**73**
Further information on the Etna earthquake	**73**

Introduction

The 26 December 2018 M_W 4.9 earthquake occurred at shallow depth (<1 km) on the eastern flank of Mount Etna and it was the strongest seismic event to hit this volcanic area during the past seventy years.
The earthquake caused severe damage up to VIII degree EMS [Quest WG, 2019] and impressive surface faulting effects along the Fiandaca Fault (FF), an important tectonic structure that borders to the south the Timpe tectonic system in the volcano's eastern flank (Figure 1). The FF runs for about 13 km between Aci Catena to the south and Monte Ilice to the north; the strike of the fault is NNW-SSE in the southern portion and NW-SE in the northern part.

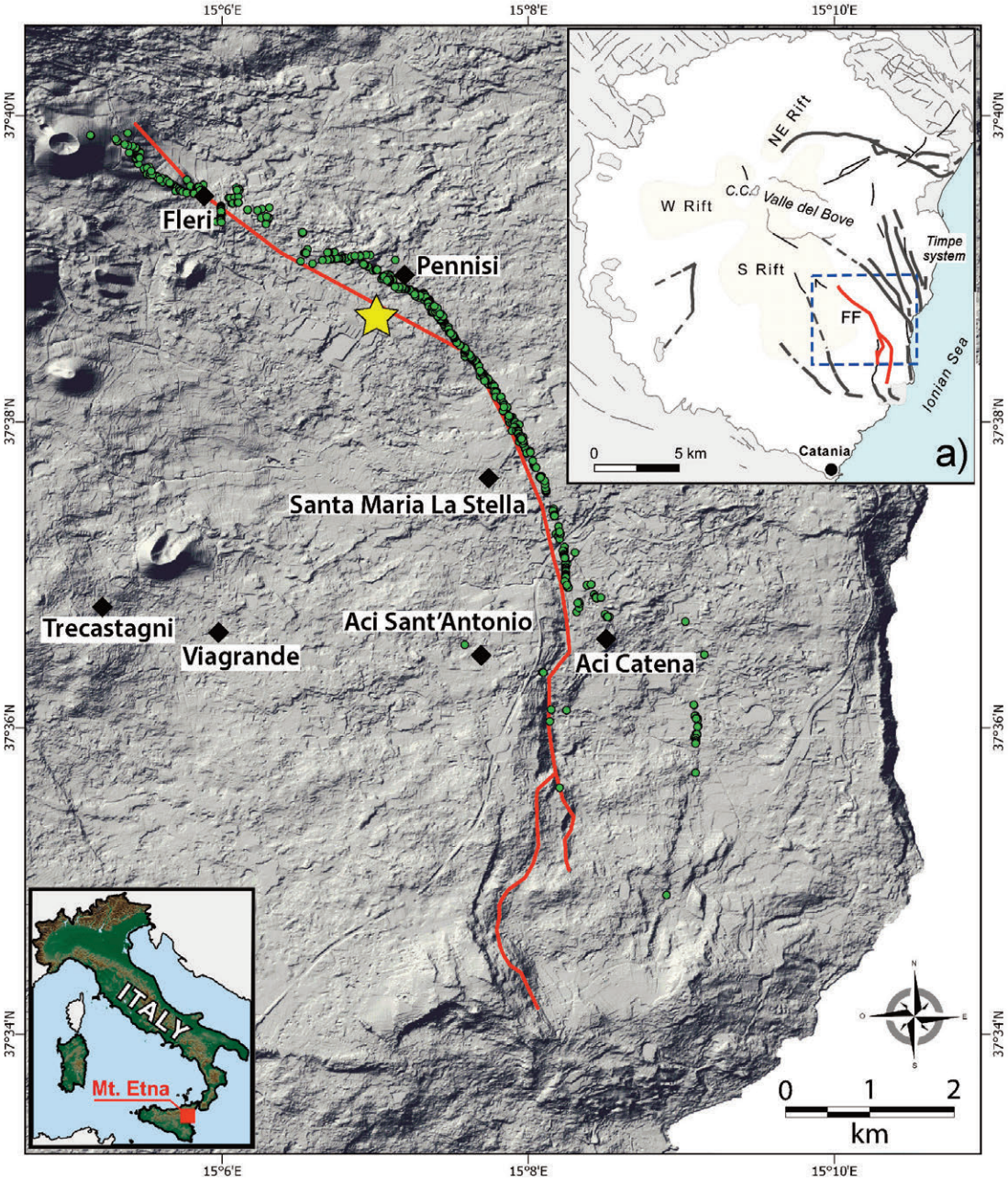


Figure 1 Location of the December 26th mainshock (yellow star) and of the geological observations of coseismic effects (green dots) produced by the earthquake. a) seismotectonic sketch of the Mt. Etna region [from Azzaro et al., 2012]: the trace of the Fiandaca Fault (FF) is shown as a solid red line, other main active faults are in bold.

The Mw 4.9 earthquake produced surface faulting along a ~8 km-long stretch of the FF. The coseismic ruptures are characterized by dominant right-oblique sense of slip, and affect the agricultural soil, paved and unpaved roads, and artifacts such as walls, pavements and buildings. Starting from 26 December, the Emergeo Working Group (http://emergeo.ingv.it) surveyed the area affected by the earthquake to recognize and map the coseismic effects induced on the natural environment [Emergeo WG, 2019]. The Group collected almost 900 points of observation in the field, including geometry and kinematics of the ruptures along the fault and in the adjacent areas (Figure 1). In this work we present a collection of pictures showing the geological effects produced in the natural or in the built environment by the 2018 Etna earthquake. The selected photographic dataset consists of 65 pictures taken between December 26th and March 26th (see location of the pictures in Figure 2). The photos are presented following a geographical direction from south to north. For each image the caption provides: geographical coordinates, date of the shot, and an explanation of the observed effect.

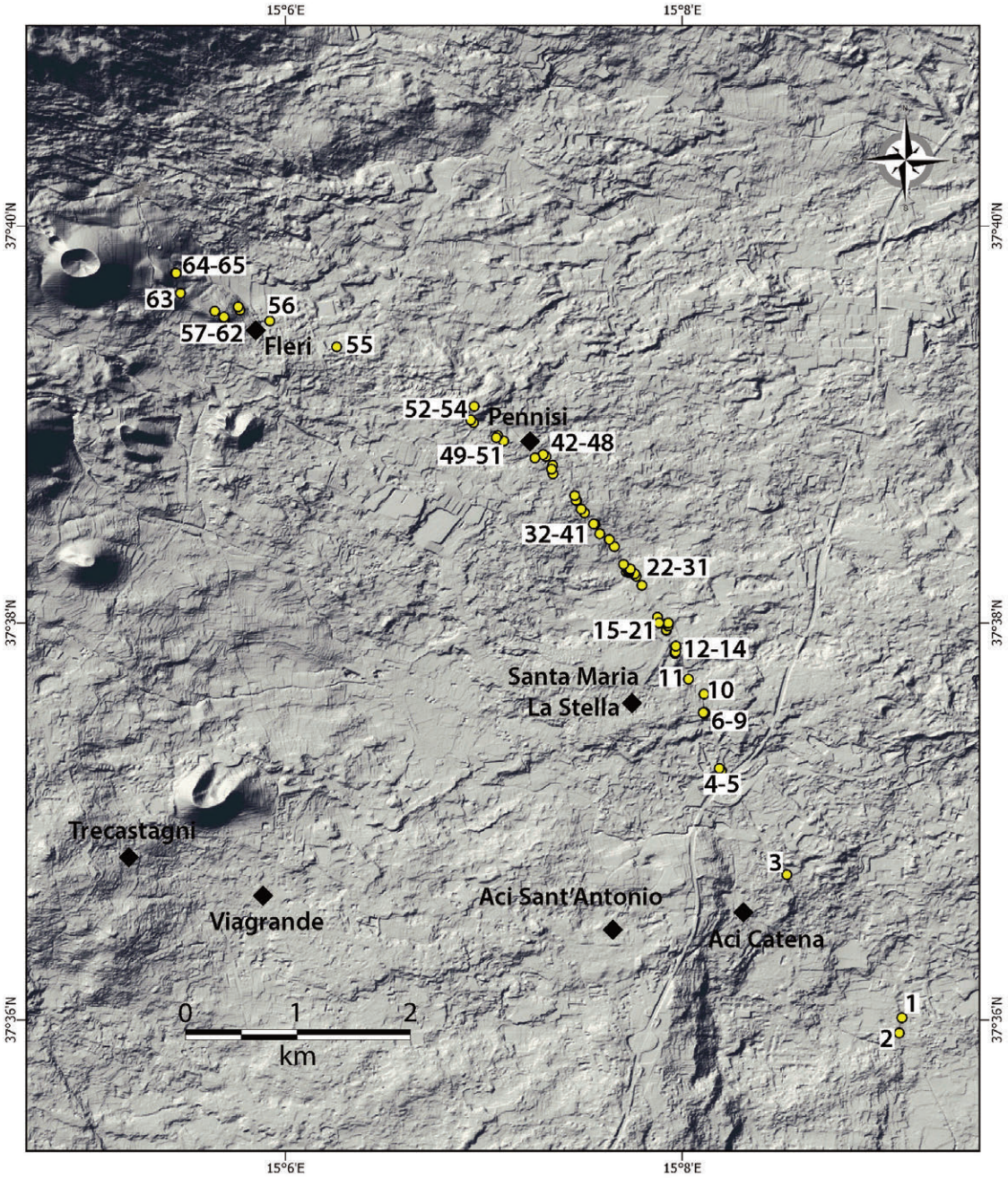


Figure 2 Location of the pictures shown in the photo gallery.

GALLERY

The photographic collection is available through a ESRI Map tour at the following link https://ingv.maps.arcgis.com/apps/MapTour/index.html?appid=8c02dd5d90dd40d3ab6598fbadc1b60d

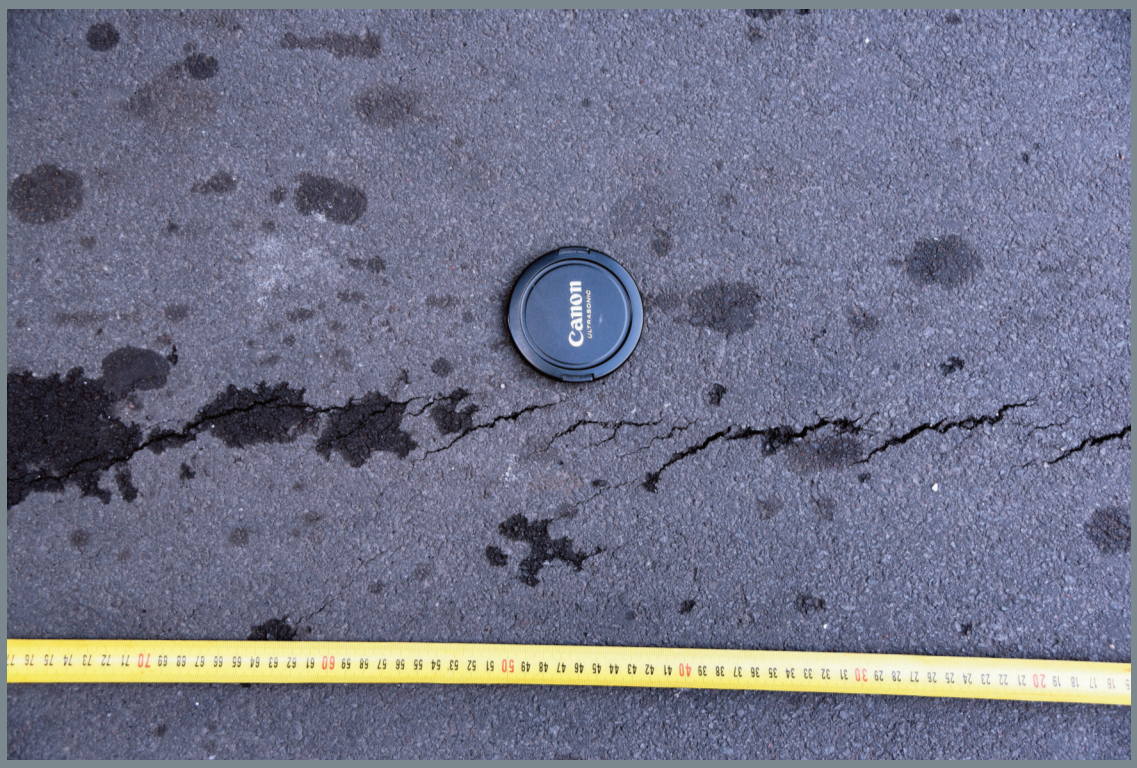


Photo 1 Lat. 37.6002 Lon. 15.1518
5 January 2019
Set of cracks on a tar road between Aci Catena and Acireale. The fractures are subparallel and arranged with a right-stepping “en échelon” fashion. The average strike of the set of cracks is 350°. In this area we mapped the southernmost coseismic effects on the ground.



Photo 2 Lat. 37.5989 Lon. 15.1516
5 January 2019
The integrity of this set of check slides (deployed between December 28th and January 4th) and of the charcoal drawings on the damaged wall of a building in the neighborhood of Aci Platani is evidence that no further deformation has occurred following the M_W 4.9 earthquake.



Photo 3 Lat. 37.6122 Lon. 15.1421
5 January 2019
Broken and disrupted concrete wall in the northern part of Aci Catena.



Photo 4 Lat. 37.6209 Lon. 15.1366
4 January 2019
Fractures with centimetric horizontal opening affect a tar road next to the A18 highway. There is evidence for right-lateral displacement along the upper main rupture. Average strike is 348°.



Photo 5 Lat. 37.6211 Lon. 15.1365
4 January 2019
This sharp fracture with centimetric horizontal opening is located 30 m northwest of photo n. 4.
It affects the asphalted road and cuts the reinforced concrete wall along its way.
Average strike is 322°.



Photo 6 Lat. 37.6258 Lon. 15.1352
4 January 2019
At this site faulting cuts through unconsolidated terrains in the foreground, then it affects and severely offsets the containment wall behind. Average strike is 349°.



Photo 7 Lat. 37.6257 Lon. 15.1352
26 March 2019
Left: set of parallel and orthogonal fractures on the tar road south of S. Maria la Stella; the thick reinforced concrete wall adjacent to the road is also affected. However, a comparison with an image of the same site shot on July 2018 (right) reveals that both the system of fractures and offset of the wall were already visible five months before the 26 December earthquake (although in a less prominent way), as a result of the aseismic creep (slow deformation occurring without release of seismic energy) that affects the southern portion of the Fiandaca Fault.



Photo 8 Lat. 37.6258 Lon. 15.1353
4 January 2019
Close-up of the site of photo n. 7.



Photo 9 Lat. 37.6258 Lon. 15.1351
26 March 2019
Just twenty meters off the location of photo n. 7 the deformation accommodated by the fault zone caused the reopening of the fracture on the road and the widening of the preexisting wall dislocation. The damage in the wall in the background and in the building behind was due to coseismic faulting. The average strike of the fractures at this location is 001°.



Photo 10 Lat. 37.6274 Lon. 15.1352
4 January 2019
A right-lateral centimetric deflection of the pavement and of the railing of this balcony can be observed in correspondence with the central lamp.



Photo 11 Lat. 37.6286 Lon. 15.1339
26 March 2019
This fracture affects a concrete road east of S. Maria la Stella. The impressive opening observed at this site was probably accomplished also through gravity effects. Average strike of the fracture is 330°.



Photo 12 Lat. 37.6308 Lon. 15.1328
29 December 2018
At this site in S. Maria la Stella the coseismic deformation affects three different manufacts: the edge of the building, the paved yard and the concrete wall. Average strike is 343°.



Photo 13 Lat. 37.6309 Lon. 15.1328
29 December 2018
Set of fractures (average strike 355°) with horizontal opening on a paved courtyard. The strong horizontal coseismic deformation caused the leaning of the grey wall and bending of the iron gate.



Photo 14 Lat. 37.6314 Lon. 15.1328
29 December 2018
The effects of surface faulting is visible along a ~15 m-wide zone at this site in the northern part of S. Maria la Stella, with open cracks and ruptures with centimetric vertical offset. Faulting extends on both sides of the picture and can be followed continuously for several hundreds of meters.



Photo 15 Lat. 37.6327 Lon. 15.1320
29 December 2018
Set of ~320°-striking coseismic ruptures with <10 cm vertical offset close to the road heading to Pennisi. Mount Etna volcano in the background.



Photo 16 Lat. 37.6327 Lon. 15.1320
29 December 2018
This thin brick wall was entirely overturned northward by seismic shaking.



Photo 17 Lat. 37.6331 Lon. 15.1322
29 December 2018
Zig-zag coseismic fracturing affects this asphalted service area and disrupts the stone wall.
Width of the photographed area ~40 m. Mount Etna volcano in the background.



Photos 18 - 19 - 20
Lat. 37.6333 Lon. 15.1321
26 March 2019
Lat. 37.6333 Lon. 15.1322
26 March 2019
Lat. 37.6338 Lon. 15.1313
26 March 2019
In some places, it is possible to observe the long-term expression of the vertical component of the Fiandaca Fault, visible as a metric morphologic scarplet originated by repeated seismic and aseismic deformation over the past decades. Here we show three examples observed along the road to Fiandaca on three parallel walkways within 50 meters distance. At these sites, a clear horizontal component occurred as well with a set of parallel, 325° to 345° striking coseismic fractures that horizontally deflect the walkways and are well visible in the sides and hedges.



Photo 21 Lat. 37.6333 Lon. 15.1314
29 December 2018
Locally, the coseismic deformation shows up as a graben-like structure originated by sub-parallel fault splays. Width of the photographed area ~15 metres.



Photo 22 Lat. 37.6365 Lon. 15.1300
25 March 2019
Multiple coseismic fault ruptures affecting the asphalt road and showing a clear dextral lateral slip on the wall and fences. Strike is 328°.



Photo 23 Lat. 37.6373 Lon. 15.1295
25 March 2019
Main coseismic fault rupture that affects the asphalt road west of Fiandaca, showing an articulated en-échelon geometry.



Photo 24 Lat. 37.6375 Lon. 15.1294
25 March 2019
Coseismic rupture producing a pressure ridge on the concrete platform. Notice how the pieces of the floor were pushed up creating a roof-like structure.



Photo 25 Lat. 37.6376 Lon. 15.1289
28 December 2018
Multiple coseismic ruptures affecting the garden and the wall of a villa ~50 m north of site n. 24.
The area between the two ruptures is clearly depressed, in a “graben” fashion.



Photo 26 Lat. 37.6377 Lon. 15.1288
28 December 2018
Graben-like features affecting the brick floor and the fence wall of a villa.



Photo 27 Lat. 37.6376 Lon. 15.1286
28 December 2018
Close-up of photo n. 26. The coseismic rupture cross-cutting the dry stone wall produced both vertical and horizontal offset.



Photo 28 Lat. 37.6378 Lon. 15.1288
28 December 2018
The solid structure of the villa deviates the coseismic rupture along the external part of the building, which results separated from the ground by important vertical and horizontal offset.



Photo 29 Lat. 37.6379 Lon. 15.1289
30 December 2018
Coseismic rupture intercepting and displacing a dry stone wall; both vertical and horizontal offsets are clearly visible. Notice the disruption of the concrete floor.



Photo 30 Lat. 37.6379 Lon. 15.1290
30 December 2018
Coseismic rupture showing clear evidence of lateral motion on a concrete floor; the damage on the dry stone wall on the left is also clearly visible. Strike 358°.



Photo 31 Lat. 37.6383 Lon. 15.1284
29 December 2018
Coseismic ruptures intercepting and horizontally displacing the wall and the fence; the lateral motion is up to tens of centimeters. The average strike is 337°.



Photo 32 Lat. 37.6397 Lon. 15.1276
29 December 2018
Collapse of a dry stone wall produced by the earthquake shaking. To glean proportions, please notice that the coseismic rupture is very close (near the feet of the surveyor).



Photo 33 Lat. 37.6404 Lon. 15.1272
30 December 2018
Coseismic fracture with gravitational sliding affecting a small terraced field; the vertical offset is up to tens of cm. Width of the photographed area ~6 metres.



Photo 34 Lat. 37.6408 Lon. 15.1264
30 December 2018
Wide coseismic rupture on a field, the opening is up to tens of cm. Strike 354°.



Photo 35 Lat. 37.6417 Lon. 15.1260
30 December 2018
Set of sub-parallel coseismic ruptures on an unpaved road. The width of the deformation zone can reach several tens of meters.



Photo 36 Lat. 37.6417 Lon. 15.1259
30 December 2018
Close-up of photo n. 35. The coseismic rupture affects the field and shows clear opening and few cm of vertical component.



Photo 37 Lat. 37.6426 Lon. 15.1251
16 January 2019
Coseismic fractures accompanied by gravitational sliding affecting a small terraced field; notice the graben-like depression within two sub-parallel ruptures. Strike 340°.



Photo 38 Lat. 37.6429 Lon. 15.1249
16 January 2019
Coseismic rupture intercepting and displacing a dry stone wall and agricultural soil. The average strike is 330°.



Photo 39 Lat. 37.6436 Lon. 15.1245
29 December 2018
Single coseismic fault rupture affecting the concrete floor and showing a complex left-stepping geometry.



Photo 40 Lat. 37.6436 Lon. 15.1244
29 December 2018
This coseismic rupture affects the concrete floor and shows a complex left-stepping geometry with minimal heave.



Photo 41 Lat. 37.6440 Lon. 15.1243
29 December 2018
Two parallel coseismic ruptures displace the soil and show up to tens of centimeters of vertical offset. Width of the photographed area is ~6 m.



Photo 42 Lat. 37.6459 Lon. 15.1225
27 December 2018
Main fracture and associated zone of deformation affecting the tar road to Pennisi.



Photo 43 Lat. 37.6464 Lon. 15.1224
25 March 2019
Some of the most outstanding ruptures were observed west of the village of Pennisi. This 50 cm-wide open fracture extends for ~80 meters on a flat ground.





Photo 44 Lat. 37.6466 Lon. 15.1224
27 January 2019
Top: main earthquake rupture with oblique, normal right-lateral sense of slip. The horizontal offset in this case locally exceeds 30 cm.
Bottom: the same spot in this picture shown as an orthophoto derived by a drone flight. Width of the area photographed by the drone is approximately 150 x 100 m.



Photo 45 Lat. 37.6463 Lon. 15.1224
28 December 2018
Detail of the open fracture in photos n. 44. INGV researchers attend to measuring the geometry and the kinematics of the rupture.



Photo 46 Lat. 37.6473 Lon. 15.1219
28 December 2018
Coseismic fracture and compressional effects on asphalt road. Newly formed ruptures originated by the December earthquake are sharp and usually marked by the absence of grass. The width of the photographed area is about 4 m.



Photo 47 Lat. 37.6475 Lon. 15.1217
16 January 2019
Open fracture with right-lateral component of motion on a paved road in Pennisi.



Photo 48 Lat. 37.6472 Lon. 15.1210
16 January 2019
Compressional and horizontal coseismic motion originated this pressure ridge on a concrete paving.



Photo 49 Lat. 37.6486 Lon. 15.1183
3 January 2019
Subparallel fractures with centimetric vertical offset in the area between Pennisi and Villaggio S. Giuseppe. Average strike of the fractures is 325°.



Photo 50 Lat. 37.6491 Lon. 15.1178
3 January 2019
A set of subparallel coseismic ruptures affects the dirt road and the surrounding soil.



Photo 51 Lat. 37.6489 Lon. 15.1177
3 January 2019
Detail of one of the coseismic fault ruptures of photo n. 50.



Photo 52 Lat. 37.6502 Lon. 15.1158
30 December 2018
At this site the zone of deformation extends for several tens of meters, and shows a set of subparallel 330-striking coseismic ruptures. Compressional effects can be observed on asphalt road.



Photo 53 Lat. 37.6504 Lon. 15.1156
30 December 2018
Detail of the vertical offset (~20 cm) of a coseismic rupture in the soil. Strike 324°.



Photo 54 Lat. 37.6516 Lon. 15.1159
30 December 2018
This brick fence wall next to Villaggio S. Giuseppe entirely collapsed and fell toward the south due to coseismic fault ruptures and intense seismic shaking.



Photo 55 Lat. 37.6565 Lon. 15.1043
30 December 2018
Coseismic rupture with horizontal offset of the brick fence wall.



Photo 56 Lat. 37.6587 Lon. 15.0987
26 December 2018
Fracturing and compression on the asphalt of a paved road in Fleri. The house suffered the collapse of the chimneys and the detachment of the plaster at the facade base.



Photo 57 Lat. 37.6589 Lon. 15.0949
3 January 2019
Coseismic fault rupture organized in a left-stepping “en échelon” fashion observed on this concrete pavement. Strike is 315°.



Photo 58 Lat. 37.6590 Lon. 15.0948
3 January 2019
This coseismic rupture affects both the fence wall and the soil with a clear vertical offset. Strike is 312°.



Photo 59 Lat. 37.6591 Lon. 15.0948
3 January 2019
Coseismic rupture affecting the soil with significant vertical offset north of San Giovannello (Fleri); it extends for several tens of meters. Average strike is 320°.



Photo 60 Lat. 37.6596 Lon. 15.0962
3 January 2019
Detail of a rupture with 10 cm vertical offset in the soil along the eastern flank of Mt. Ilice.



Photo 61 Lat. 37.6599 Lon. 15.0960
3 January 2019
Set of sub-parallel fractures in the soil. Gravity effects enhanced the deformations observed at this site.



Photo 62 Lat. 37.6595 Lon. 15.0940
3 January 2019
The coseismic rupture produced an opening in the concrete floor and clear horizontal dislocation of the curb. The average strike is 321°.



Photo 63 Lat. 37.6611 Lon. 15.0911
10 January 2019
Parallel longitudinal fractures caused failure and sliding of the pavement side. Strike is 270°.



Photo 64 Lat. 37.6628 Lon. 15.0907
17 January 2019
Vertical offset of a coseismic rupture in the soil along the eastern flank of Monte Ilice.
The average strike is 310°. The width of the photographed area is about 15 m.



Photo 65 Lat. 37.6627 Lon. 15.0908
10 January 2019
Detail of photo n. 64 with ~20 cm vertical offset and opening.

Acknowledgements

We want to thank the local population for their willingness to access their properties. The manuscript has been carefully revised by U. Fracassi. Photographs taken by: R. Azzaro, C.A. Brunori, M. Caciagli, M. Cantarero, F.R. Cinti, R. Civico, L. Cucci, S. D'Amico, P.M. De Martini, M.T. Mariucci, S. Pucci, T. Ricci, A. Smedile.

References

Azzaro R., S. Branca, K. Gwinner, and M. Coltelli, (2012). *The volcano-tectonic map of Etna volcano, 1:100.000 scale: an integrated approach based on a morphotectonic analysis from high-resolution DEM constrained by geologic, active faulting and seismotectonic data*. Italian Journal of Geosciences, 131, 153-170.

Emergeo WG (2019). *Il terremoto etneo del 26 dicembre 2018, M_W4.9: rilievo degli effetti di fagliazione cosismica superficiale*. Rapporto INGV n. 1 del 21/01/2019, 9 pp., doi 10.5281/zenodo.2545555.

Quest WG (2019). *Il terremoto etneo del 26 dicembre 2018, M_W4.9: rilievo degli effetti macrosismici*. Rapporto INGV n. 1 del 06/02/2019, 9 pp., doi:10.5281/zenodo.2558168 http://www.ingv.it/quest/index.php/rilievi-macrosismici/36-etna-26-12-2018-mw-4-9/file

Further information on the Etna earthquake:

INGV site
http://cnt.rm.ingv.it/event/21285011

INGV Blog Terremoti
https://ingvterremoti.wordpress.com/2019/03/06/la-fagliazione-superficiale-prodotta-dal-terremoto-etneo-del-26-dicembre-2018-mw-4-9/#more-13764

QUADERNI di GEOFISICA

ISSN 1590-2595 http://istituto.ingv.it/it/le-collane-editoriali-ingv/quaderni-di-geofisica.html/

I QUADERNI DI GEOFISICA (QUAD. GEOFIS.) accolgono lavori, sia in italiano che in inglese, che diano particolare risalto alla pubblicazione di dati, misure, osservazioni e loro elaborazioni anche preliminari che necessitano di rapida diffusione nella comunità scientifica nazionale ed internazionale. Per questo scopo la pubblicazione on-line è particolarmente utile e fornisce accesso immediato a tutti i possibili utenti. Un Editorial Board multidisciplinare ed un accurato processo di peer-review garantiscono i requisiti di qualità per la pubblicazione dei contributi. I QUADERNI DI GEOFISICA sono presenti in "Emerging Sources Citation Index" di Clarivate Analytics, e in "Open Access Journals" di Scopus.

QUADERNI DI GEOFISICA (QUAD. GEOFIS.) welcome contributions, in Italian and/or in English, with special emphasis on preliminary elaborations of data, measures, and observations that need rapid and widespread diffusion in the scientific community. The on-line publication is particularly useful for this purpose, and a multidisciplinary Editorial Board with an accurate peer-review process provides the quality standard for the publication of the manuscripts. QUADERNI DI GEOFISICA are present in "Emerging Sources Citation Index" of Clarivate Analytics, and in "Open Access Journals" of Scopus.

RAPPORTI TECNICI INGV

ISSN 2039-7941 http://istituto.ingv.it/it/le-collane-editoriali-ingv/rapporti-tecnici-ingv.html/

I RAPPORTI TECNICI INGV (RAPP. TEC. INGV) pubblicano contributi, sia in italiano che in inglese, di tipo tecnologico come manuali, software, applicazioni ed innovazioni di strumentazioni, tecniche di raccolta dati di rilevante interesse tecnico-scientifico. I RAPPORTI TECNICI INGV sono pubblicati esclusivamente on-line per garantire agli autori rapidità di diffusione e agli utenti accesso immediato ai dati pubblicati. Un Editorial Board multidisciplinare ed un accurato processo di peer-review garantiscono i requisiti di qualità per la pubblicazione dei contributi.

RAPPORTI TECNICI INGV (RAPP. TEC. INGV) publish technological contributions (in Italian and/or in English) such as manuals, software, applications and implementations of instruments, and techniques of data collection. RAPPORTI TECNICI INGV are published online to guarantee celerity of diffusion and a prompt access to published data. A multidisciplinary Editorial Board and an accurate peer-review process provide the quality standard for the publication of the contributions.

MISCELLANEA INGV

ISSN 2039-6651 http://istituto.ingv.it/it/le-collane-editoriali-ingv/miscellanea-ingv.html

MISCELLANEA INGV (MISC. INGV) favorisce la pubblicazione di contributi scientifici riguardanti le attività svolte dall'INGV. In particolare, MISCELLANEA INGV raccoglie reports di progetti scientifici, proceedings di convegni, manuali, monografie di rilevante interesse, raccolte di articoli, ecc. La pubblicazione è esclusivamente on-line, completamente gratuita e garantisce tempi rapidi e grande diffusione sul web. L'Editorial Board INGV, grazie al suo carattere multidisciplinare, assicura i requisiti di qualità per la pubblicazione dei contributi sottomessi.

MISCELLANEA INGV (MISC. INGV) favours the publication of scientific contributions regarding the main activities carried out at INGV. In particular, MISCELLANEA INGV gathers reports of scientific projects, proceedings of meetings, manuals, relevant monographs, collections of articles etc. The journal is published online to guarantee celerity of diffusion on the internet. A multidisciplinary Editorial Board and an accurate peer-review process provide the quality standard for the publication of the contributions.

Coordinamento editoriale e impaginazione
Francesca DI STEFANO, Rossella CELI
Istituto Nazionale di Geofisica e Vulcanologia

Progetto grafico e impaginazione
Barbara ANGIONI
Istituto Nazionale di Geofisica e Vulcanologia

©2018
Istituto Nazionale di Geofisica e Vulcanologia
Via di Vigna Murata, 605
00143 Roma
t. +39 06518601

www.ingv.it



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

