

Research into deadly 2016 Italian earthquakes could improve future seismic forecasts

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Location of survey site at rupture across a road near Castelluccio, Italy. The rupture occurred during the third earthquake in the seismic sequence and gives researchers a record of the deformation. Credit: Laura Gregory, University of Leeds

The timing and size of three deadly earthquakes that struck Italy in 2016 may have been pre-determined, according to new research that could improve future earthquake forecasts.

A joint British-Italian team of geologists and seismologists have shown that the clustering of the three quakes might have been caused by the arrangement of a cross-cutting network of underground faults.

The findings show that although all three earthquakes occurred on the same major fault, several smaller faults prevented a single massive [earthquake](#) from occurring instead and also acted as pathways for naturally occurring fluids that triggered later earthquakes.

The cluster of three earthquakes, termed a "seismic sequence" by seismologists, each had magnitudes greater than six and killed more than 300 people in Italy's Apennine mountains between 24 August and 30 October 2016.

The research, led by Durham University, UK, comes ahead of the second anniversary of the start of the earthquake sequence.

The study is published in the journal *Earth and Planetary Science Letters*.

The researchers say the findings could have wider implications for the study of seismic hazards, enabling scientists to better understand potential earthquake sequences following a quake.

Dr. Richard Walters, Assistant Professor in the Department of Earth Sciences, Durham University, said: "These results address a long-standing mystery in earthquake science—why a major fault system sometimes fails in a single large earthquake that ruptures its entire

length, versus failing in multiple smaller earthquakes drawn-out over months or years.

"Our results imply that even though we couldn't have predicted when the earthquake sequence would start, once it got going, both the size and timing of the major earthquakes may have been pre-determined by the arrangement of faults at depth.

"This is all information we could hypothetically know before the event, and therefore, this could be a hugely important avenue for improving future earthquake forecasts."



Prominent surface rupture on the side of Mt Vettore, Italy, with the town of Castelluccio in the background. Credit: Laura Gregory, University of Leeds

Dr. Walters and the team used satellite data to estimate which part of the fault failed in each earthquake, and compared this pattern with the location and timing of thousands of tiny aftershocks throughout the seismic sequence.

They found that intersections of small faults with the main fault system separated each of the three largest earthquakes, strongly suggesting these intersections stop the growth of each earthquake and prevent the faults failing in a single large event.

But in addition, the scientists also found that after the first earthquake, thousands of aftershocks crept northwards along these same fault intersections at a rate of around 100 metres per day, in a manner consistent with naturally occurring water and gas being pumped along the faults by the first earthquake on 24 August, 2016.

The second earthquake, on the 26 October, occurred exactly when these fluids reached its location, therefore controlling the relative timing of failure.

Dr. Walters added: "It was a big surprise that these relatively small faults were having such a huge influence over the whole sequence.

"They stop the first earthquake in its tracks, and then they channel the fluids that start the sequence up again months later. No-one's ever seen this before."

Co-author Dr. Laura Gregory, in the School of Earth and Environment,

at the University of Leeds, UK, said it was important to understand whether or not a [fault](#) fails in a seismic sequence, and that the team's results were only made possible by combining a varied array of different datasets.

Dr. Gregory said: "A seismic sequence has vastly different implications for seismic hazard compared to a single large earthquake. If the faults in Italy in 2016 had failed together in one big event, the impact on the local population would have been much worse.

"This is the first time we've ever had this quality of modern data over one of these earthquake sequences, and bringing together a range of specialists was key for unpicking how the earthquakes related to one another.

"I was scrambling over the mountainside immediately after each earthquake with British and Italian colleagues, measuring the metre-high cliffs that had suddenly formed. Meanwhile, other members of our team were analysing data from seismometers stationed around the world, or were mapping the tiny bending of the ground around the faults using satellites orbiting the planet at 500 miles altitude."

More information: R.J. Walters et al, Dual control of fault intersections on stop-start rupture in the 2016 Central Italy seismic sequence, *Earth and Planetary Science Letters* (2018). [DOI: 10.1016/j.epsl.2018.07.043](#)

Provided by Durham University

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