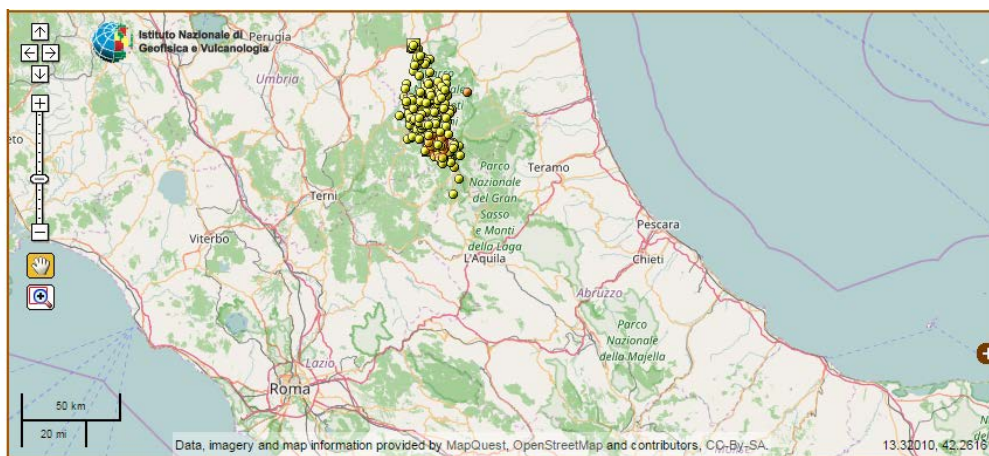


## The 2016 Central Italy Earthquake Sequence

Paul Somerville, Risk Frontiers

An earthquake of magnitude 6.6 with an epicentre 132 km northeast of Rome and 67 km east of Perugia, near the epicentre of last week's earthquakes, occurred on October 30 2016 at 7:40 am local time. The earthquake was the strongest to hit Italy, one of the world's most seismically active countries, since 1980. The locations of the recent earthquakes in relation to Rome and the 2009 L'Aquila earthquake, which resulted in trials of seismologists (RF Briefing Notes 172, 245, and 285), are shown in Figure 1.



**Figure 1.** Location of the recent earthquakes in relation to L'Aquila (S) and Rome (SW).

The October 30 earthquake, whose location is shown by the blue teardrop symbol on the left side of Figure 2, occurred at the northwest end of the region, shown by a full ellipse in both panels of Figure 2, that experienced a sequence of earthquakes in August including a magnitude 6.2 earthquake on August 24 that killed 297 people. A magnitude 6.1 earthquake occurred to the north on October 26; its location is shown on the left side of Figure 2, which was made before the October 30 event.

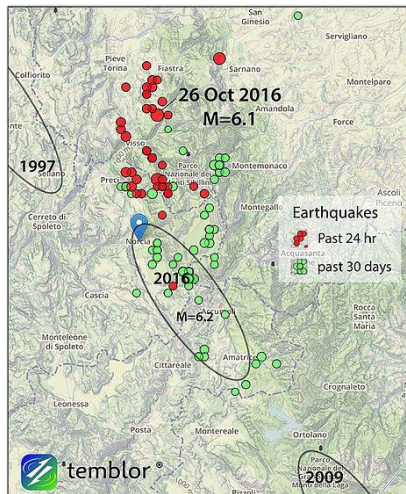
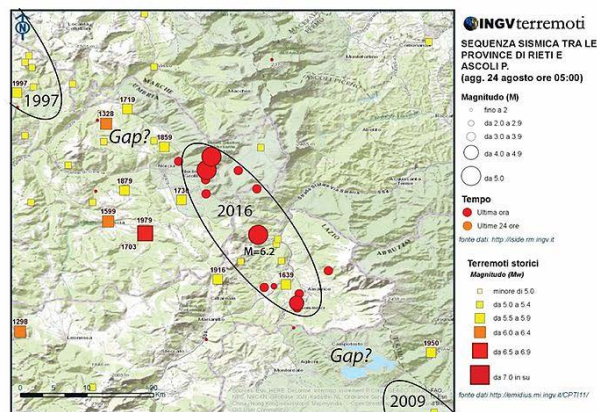


Figure from Temblor Insights, published on 29 Aug 2016



**Figure 2.** Locations of the August and October Earthquakes. Source: Temblor, 2016.

The October 30 earthquake severely impacted the largely-abandoned towns of Norcia, Castelsantangelo, Preci and Visso, where residents had left their homes to sleep in cars or moved to the coast following the earthquakes of preceding weeks.

The earthquake caused widespread damage to the ancient town of Norcia, reportedly injuring about twenty people but so far remarkably not causing any known deaths, presumably because of evacuations prompted by the earthquake sequence that occurred during the preceding week. St. Benedict cathedral, named in honour of the Catholic saint who was born in Norcia in the year 480, crumbled, with only its facade still standing.

“As far as people are concerned, the situation is positive but many buildings are in a critical state in historic centres and there are problems with electricity and water supplies,” Fabrizio Curcio told reporters. “Everything collapsed. I can see columns of smoke, it’s a disaster, a disaster,” said Marco Rinaldi, the mayor of Ussita, one of the scenic mountain villages hit hardest by the earthquake. “I was sleeping in my car, I saw hell break out,” he was quoted as saying.

The earthquakes that have occurred in central Italy over the last two months could continue in a domino effect with one large earthquake triggering the next one along the central Apennine fault system, according to Gianluca Valensise, a seismologist at Italy’s National Institute for Geophysics and Volcanology. He told Reuters that there was a link between the August 24 earthquake and all those that have followed. Italy’s Apennine mountains, which run from the Liguria region in the northwest to the southern island of Sicily, are dominated by a chain of faults in the earth’s crust, each one averaging about 10-20 kilometers in length. “An earthquake measuring 6 or larger creates stresses that are redistributed across adjacent faults and can cause them to rupture, and this is probably what we have seen since August,” Valensise said. “This process can continue indefinitely, with one big earthquake weakening a sister fault in a domino process that can cover hundreds of kilometers, in principle.”

Valensise said Italy had seen something resembling the sequence of earthquakes in Calabria, in Italy’s southern toe, in 1783 when there were five major earthquakes of magnitude 6.5 or larger in less than two months. More recently, there were three earthquakes around Assisi in central Italy in 1997, the first one of magnitude 6.4 which killed 11 people, another the following day, and another around 20 days later with many smaller ones in between. “That sequence was similar to what we are seeing now but this is on a larger scale,” Valensise said.

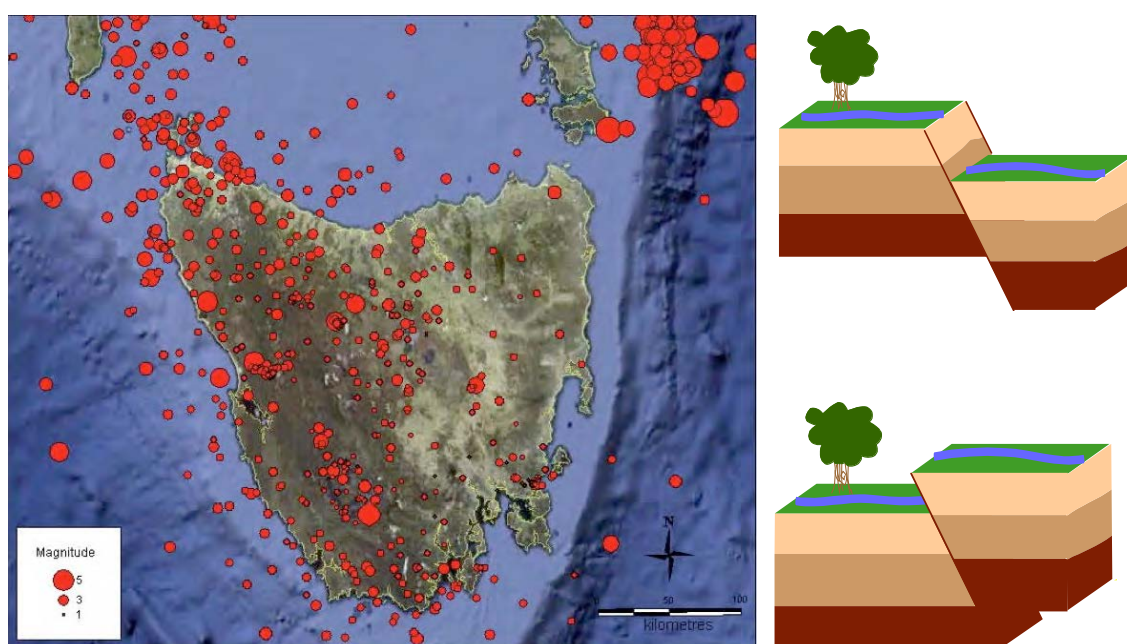
Looking ahead, he said it was certain there would be aftershocks from Sunday’s earthquake for “at least a few weeks,” but it was not possible to say whether there would be any more big earthquakes. The risk is that, with faults to the northwest and southeast of the central region most recently hit, “if the process of stress redistribution finds other faults close to rupture level they could go off in the next days or weeks,” he said.

The president of Italy’s National Institute for Geophysics and Volcanology, Carlo Doglioni, said that the intense activity along a series of faults in the region was not anomalous. He said there was a similar sequence of three earthquakes within a period of months in 1703, adding that “it is normal for the Apennines,” where there are a series of interdependent faults.

Could a sequence of earthquakes like the one in central Italy occur in Australia? The tectonic settings are very different: the Appenine mountains that form Italy’s backbone are on a plate boundary and form an accretionary wedge caused by westward subduction of the Adria micro-plate (east of Italy) beneath Eurasia; the earthquakes are caused by normal faulting due to horizontal extension of the crust (top right panel of Figure 3). In contrast, Australia is a stable continental region remote from plate boundaries with earthquakes caused mainly by reverse faulting due to horizontal shortening of the crust (bottom right panel of Figure 3).

However, the sequence of numerous earthquakes that occurred off the northeast coast of Tasmania between 1883 and 1892 (left side of Figure 3) included four events of magnitude 6 or larger and lasted much longer than the current sequence in Central Italy and the recent sequence in the Canterbury Plain in the South Island of New Zealand. This indicates that at least some regions of Australia may have the potential to generate earthquake sequences like the one in Central Italy.

At first glance, there seems little to connect the Appenines with the continental margin off northeastern Tasmania. However, it is known that the seismic potential of the extended margins (edges of stable continents formed by rifting on normal faults) is different from that of the non-extended (non-rifted) interiors of continents in three respects: earthquakes are more frequent, maximum magnitudes are larger, and the range of source depths is also larger. This suggests that there may be additional differences, one of which might relate to the potential for clusters of large magnitude earthquakes. Although the faults off northeastern Tasmania were formed as normal faults, like those in the Appenines, they have presumably been reactivated by the high compressional stress across the Tasman sea due to the collision between the Pacific Plate and the Australian plate along the Alpine fault in the south island of New Zealand, and are presumably currently acting as reverse faults.



**Figure 3.** Left: Seismicity of Tasmania, 1880 – 2010. Source: Payne et al., 2010. Right: Schematic diagrams of normal fault (top) and reverse fault (bottom).

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