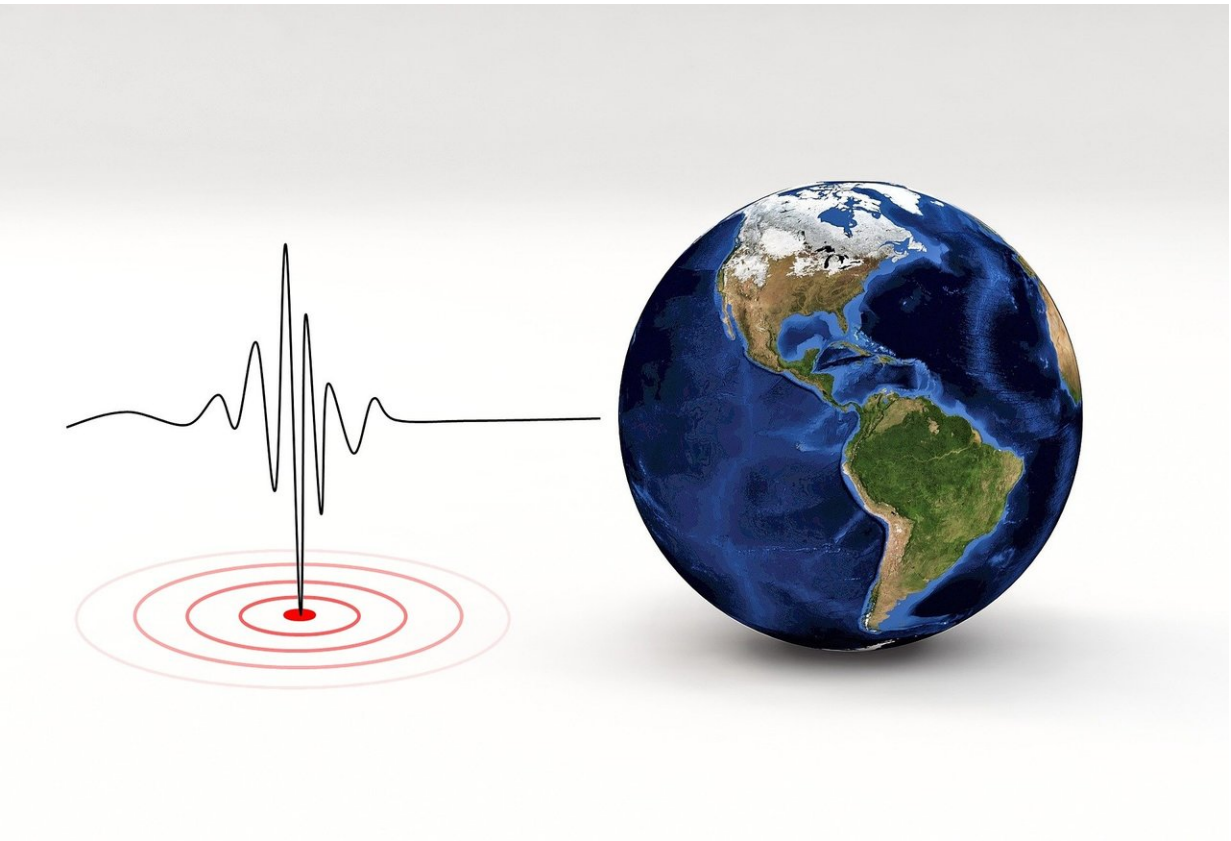
Magnitude of Great Lisbon Earthquake may have been lower than previous estimates

January 7 2020



Credit: CC0 Public Domain

The magnitude of the Great Lisbon Earthquake event, a historic and devastating earthquake and tsunami that struck Portugal on All Saints' Day in 1755, may not be as high as previously estimated.

In his study published in the *Bulletin of the Seismological Society of America*, Joao F. B. D. Fonseca at the Universidade de Lisboa used macroseismic data—contemporaneous reports of shaking and damage—from Portugal, Spain and Morocco to calculate the earthquake 's magnitude at 7.7. Previous estimates placed the earthquake at magnitude 8.5 to 9.0.

Fonseca's analysis also locates the epicenter of the 1755 earthquake offshore of the southwestern Iberian Peninsula, and suggests the rupture was a complicated one that may have involved faulting onshore as well. This re-evaluation could have implications for the seismic hazard map of the region, he said.

The current maps are based on the assumption that most of the region's crustal deformation is contained in large offshore earthquakes, without a significant onshore component. "While the current official map assigns the highest level of hazard to the south of Portugal, gradually diminishing toward the north, the interpretation now put forward concentrates the hazard in the Greater Lisbon area," said Fonseca.

The 1755 Lisbon earthquake and tsunami event, along with the fires it caused that burned for hours in the city, is considered one of the deadliest earthquake events in history, leading to the deaths of about 12,000 people. The devastation had a significant impact on Portugal's economy and its political power within Europe, and its philosophical and theological implications were widely discussed by Enlightenment scholars from Voltaire to Immanuel Kant.

The widespread devastation led earlier seismologists to estimate a high magnitude for the earthquake. With modern modeling techniques and a better understanding of the region's tectonics, Fonseca thought it important to revisit the estimate. The 1755 earthquake is unusual in that it produced extreme damage hundreds of kilometers from its epicenter

without any of the accompanying geological conditions—like amplification of seismic waves in a loose sedimentary basin, for instance—that normally cause such severe site effects.

"Explanations put forward for the extreme damage in Lisbon tend to invoke abnormally low attenuation of seismic energy as the waves move away from the epicenter, something that is not to be observed anywhere else in the globe," Fonseca explained. "Current attempts to harmonize seismic hazard assessment across Europe are faced with large discrepancies in this region, which need to be investigated and resolved for a better mitigation and management of the risk through building codes and land use planning."

Fonseca used 1206 points of macroseismic data to reassess the 1755 earthquake's magnitude and epicenter. The analysis and modeling also indicate that some of the very high earthquake intensities reported in the region's nearby Lower Tagus Valley and the Algarve may have been due to two separate onshore earthquakes in these locations. These earthquakes, which took place a few minutes after the offshore rupture, may have been triggered by the first earthquake, Fonseca suggests.

The new magnitude estimate for the 1755 earthquake is similar to that of another large regional earthquake, the 1969 magnitude 7.8 Gorringe Bank quake. However, the damage from the Gorringe Bank earthquake was much less severe, possibly in part because the onshore faults had not accumulated enough stress to make them "ripe to rupture," Fonseca says. "The Lower Tagus Fault, near Lisbon, ruptured in 1909, in 1531 and likely in 1344. It is plausible that it was good to go in 1755, but still halfway through the process of accumulating stress in 1969."

Fonseca also suggests that the destructive size of the 1755 accompanying tsunami might be due more to the presence of a large sedimentary body produced by past subduction, called an accretionary wedge, on the ocean

bottom in the Gulf of Cadiz. When a fault rupture moves through this wedge, it can generate a tsunami even without an extreme magnitude rupture, he said.

More information: Joao F. B. D. Fonseca. A Reassessment of the Magnitude of the 1755 Lisbon Earthquake. *Bulletin of the Seismological Society of America* (2020) DOI: 10.1785/0120190198

Provided by Seismological Society of America