Sumatra quake was part of crustal plate breakup: Study shows huge jolt measured 8.7, ripped at least 4 faults

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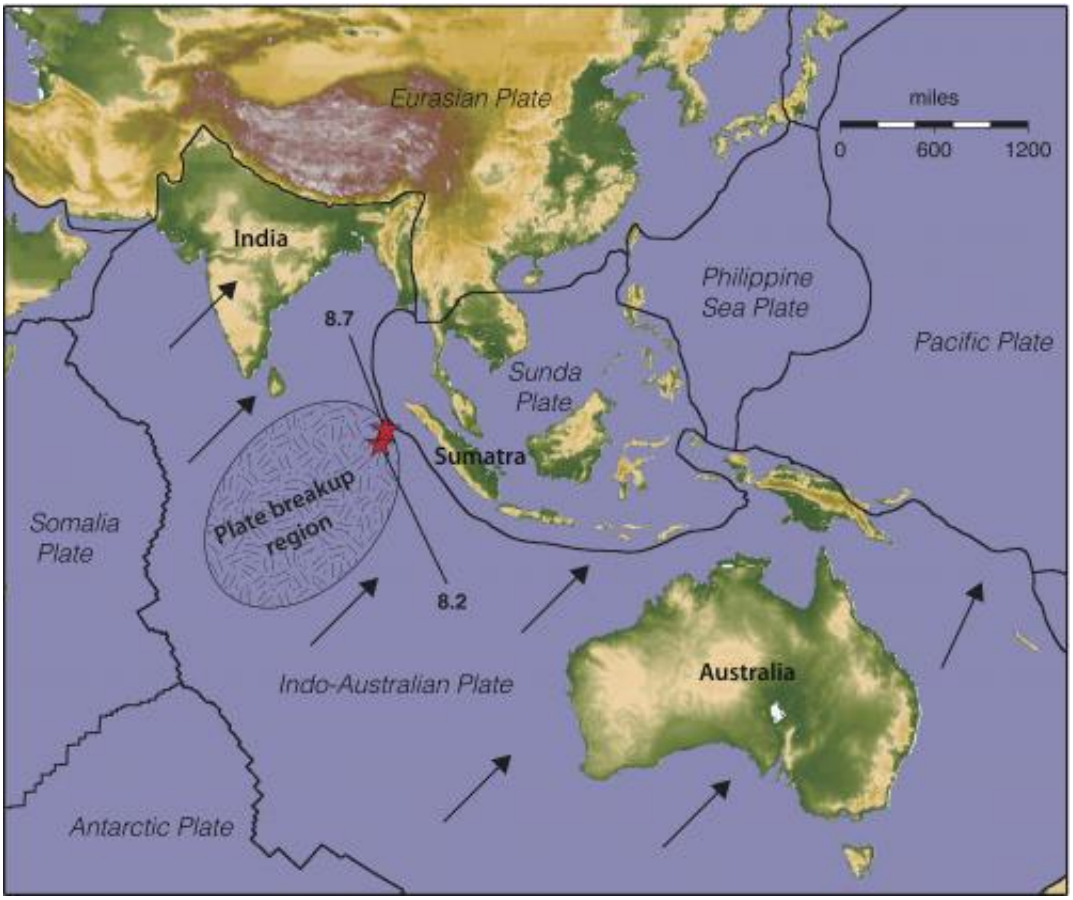

This map of the Indian Ocean region shows boundaries of Earth's tectonic plates in the area, and the epicenters (red stars) of two great earthquakes that happened April 11, 2012. A new study from the University of Utah and University of California, Santa Cruz, says the main shock measured 8.7 in magnitude, about 40 times larger than the previous estimate of 8.6. An 8.2-magnitude quake followed two hours later.The scientists explain how at least four faults ruptured during the

8.7 main shock, and how both great quakes are likely part of the breakup of the Indo-Australian Plate into separate subplates. The northeastward-moving plate is breaking up over scores of millions of years because the western part of the plate is bumping into Asia and slowing down, while the eastern part is sliding more easily beneath Sumatra and the Sunda plate. Credit: Keith Koper, University of Utah Seismograph Stations.

Seismologists have known for years that the Indo-Australian plate of Earth's crust is slowly breaking apart, but they saw it in action last April when at least four faults broke in a magnitude-8.7 earthquake that may be the largest of its type ever recorded.

The great Indian Ocean quake of April 11, 2012 previously was reported as 8.6 magnitude, and the new estimate means the quake was 40 percent larger than had been believed, scientists from the University of Utah and University of California, Santa Cruz, report in the Sept. 27 issue of the journal *Nature*.

The quake was caused by at least four undersea fault ruptures southwest of Sumatra, Indonesia, within a 2-minute, 40-second period. It killed at least two people, and eight others died from heart attacks. The quake was felt from India to Australia, including throughout South Asia and Southeast Asia.

If the four ruptures were considered separate quakes, their magnitudes would have been 8.5, 7.9, 8.3 and 7.8 on the "moment magnitude" scale used to measure the largest quakes, the scientists report.

The 8.7 main shock broke three faults that were parallel but offset from each other – known as en echelon faults – and a fourth fault that was perpendicular to and crossed the first fault.

The new study concludes that the magnitude-8.7 quake and an 8.2 quake two hours later were part of the breakup of the Indian and Australian subplates along a yet-unclear boundary beneath the Indian Ocean west of Sumatra and southeast of India – a process that started roughly 50 million years ago and that will continue for millions more.

"We've never seen an earthquake like this," says study co-author Keith Koper, an associate professor geophysics and director of the University of Utah Seismograph Stations. "This is part of the messy business of breaking up a plate. … This is a geologic process. It will take millions of years to form a new plate boundary and, most likely, it will take thousands of similar large quakes for that to happen."

All four faults that broke in the 8.7 quake and the fifth fault that ruptured in the 8.2 quake were strike-slip faults, meaning ground on one side of the fault moves horizontally past ground on the other side.

The great quake of last April 11 "is possibly the largest strike-slip earthquake ever seismically recorded," although a similar size quake in Tibet in 1950 was of an unknown type, according to the new study, which was led by two University of California, Santa Cruz, seismologists: graduate student Han Yue and Thorne Lay, a professor of Earth and planetary sciences. The National Science Foundation funded the study.

The 8.7 jolt also "is probably the largest intraplate [within a single tectonic plate of Earth's crust] ever seismically recorded," Lay, Yue and Koper add. Most of Earth's earthquakes occur at existing plate boundaries.

The researchers cannot be certain the April great quake was the largest intraplate quake or the largest strike-slip quake because "we are comparing it against historic earthquakes long before we had modern

seismometers," says Koper.

Why the Great Quake Didn't Unleash Major Tsunamis

Koper says the 2012 quakes likely were triggered, at least in part, by changes in crustal stresses caused by the magnitude-9.1 Sumatra-Andaman earthquake of Dec. 26, 2004 – a jolt that generated massive tsunamis that killed most of the 228,000 victims in the Indian Ocean region.

The fact the 8.7 and 8.2 quakes were generated by horizontal movements along seafloor strike-slip faults – not by vertical motion along thrust faults – explains why they didn't generate major tsunamis. The 8.7 quake caused small tsunamis, the largest of which measured about 12 inches in height at Meulaboh, Indonesia, according to the U.S. Geological Survey.

Without major tsunamis, the great earthquake caused "very little damage and death, especially for this size of an earthquake, because it happened in the ocean and away from coastlines," and on strike-slip faults, says Koper.

The researchers studied the quake using a variety of methods to analyze the seismic waves it generated. Because the same data can be interpreted in various ways, Koper says it is conceivable that more than four fault segments broke during the 8.7 quake – conceivably five or even six – although four fault ruptures is most likely.

Breaking Up is Hard to Do

The Indo-Australian plate is breaking into two or perhaps three pieces (some believe a Capricorn subplate is separating from the west side of

the Indian subplate). The magnitude-8.7 and 8.2 great quakes on April 11 occurred over a broad area where the India and Australian subplates are being sheared apart.

"What we're seeing here is the Indo-Australian plate fragmenting into two separate plates," says Lay.

The breakup of the northeast-moving Indo-Australian plate is happening because it is colliding with Asia in the northwest, which slows down the western part of the plate, while the eastern part of the plate continues moving more easily by diving or "subducting" under the island of Sumatra to the northeast. The subduction zone off Sumatra caused the catastrophic 2004 magnitude-9.1 quake and tsunami.

Seismic analysis shows the April 11 quakes "involve rupture of a very complex network of faults, for which we have no documented precedent in recorded seismic history," the researchers write.

The analysis revealed this sequence for the faults ruptures that generated the 8.7 quake, and the estimated fault rupture lengths and slippage amounts:

— The quake began with the 50-second rupture of a fault extending west-northwest to east-southeast, with an epicenter a few hundred miles southwest of Sumatra. The fault ruptured along a roughly 90-mile length, breaking "bilaterally" both west-northwestward and east-southeastward, and also at least 30 miles deep, "almost ripping through the whole plate," Koper says. The seafloor on one side of the fault slipped about 100 feet past the seafloor on the fault's other side.

— The second fault, which slipped about 25 feet, began to rupture 40 seconds after the quake began. This rupture extended an estimated 60 miles to 120 miles north-northeast to south-southwest – perpendicular to

the first fault and crossing it.

— The third fault was parallel to the first fault and about 90 to the miles southwest of it. It started breaking 70 seconds after the quake began and ruptured along a length of about 90 miles. This fault slipped about 70 feet.

— The fourth fault paralleled the first and third faults, but was to the northwest of both of them. It began to rupture 145 seconds after the quake began and continued to do so for 15 seconds until the quake ended after a total time of 2 minutes and 40 seconds. The fault rupture was roughly 30 miles to 60 miles long. The ground on one side of this fault slipped about 20 feet past ground on the other side.

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