**Extraordinary earthquakes in the Indian Ocean, 11th of April, 2012**

By Kerry Sieh

On 11-April 2012, at 3:38 PM local time, an exceptionally large earthquake with a magnitude of 8.6 occurred in the Indian Ocean, 430 km southwest from Banda Aceh. Another major shock (M 8.2) struck about two hours later and 200 km to the south, as well as numerous aftershocks. Both great earthquakes caused strong shaking in Sumatra and south-eastern India. Many people in Sumatra made the safest choice by fleeing to high ground immediately after feeling the strong earthquake.

*Different from the 2004 Aceh-Andaman earthquake*

The 11-April 2012 earthquakes were very different from the catastrophic Sumatran megathrust earthquakes that struck the region in 2004 (M 9.2), 2005 (M 8.7) and 2007 (M 8.4). The megathrust earthquakes resulted from the Indian and Australian plates diving under (subducting beneath) the Sunda/Eurasian plate. Megathrust earthquakes suddenly move the seafloor and sea water up, or down, by many meters, as in Aceh in 2004 and Japan in 2011. This generates a series of large waves called a “tsunami” that can travel very far.

In contrast, the 11-April earthquakes were caused by horizontal sliding on strike-slip faults on the deep seafloor. This side-to-side motion does not produce a large tsunami. News reports indicate that the 11-April tsunami was generally less than a meter tall in Aceh.

Nevertheless, coastal populations responded correctly by immediately evacuating to high ground as soon as they felt the earthquake. It takes time for scientists to determine the tsunami potential of a large earthquake, and warnings do not reach all areas in time. The water does not always recede before a tsunami, so waiting to watch the ocean is not a safe thing to do after a large earthquake.

*The largest strike-slip earthquake ever recorded?*

The first and largest of the 11-April earthquakes might rank as the largest strike-slip earthquake ever recorded. Although more work will be needed in the next days and weeks to understand the exact source of the earthquake, preliminary seismological results from observatories around the world suggest that the earthquake resulted from horizontal sliding on several strike-slip fault patches trending either north-northeast or west-northwest, up to perhaps 250 km long. The corresponding fault ruptures may have extended from the seafloor, through the 5 km-thick oceanic crust and down into the uppermost mantle, to a depth of perhaps 30km. The fact that the uppermost mantle is more rigid than the crust may partly account for the large magnitude.

It is also exceptional that the M 8.6 earthquake triggered a magnitude M 8.2 earthquake only two hours later, 200 km to the southwest. This second earthquake apparently shows a simpler rupture, mostly on a north-northeast-trending strike-slip fault.

*New insights into a mysterious plate boundary*

Scientists have long been puzzled by the nature, location, and even definition of the boundary between the Indian and Australian plates in the depths of the Indian Ocean. The Australian plate is moving relatively northwards about 1 cm-per-year faster than the Indian plate; this difference in velocity causes strain between the two plates. The 11-April earthquakes provide important new evidence that this strain is reactivating a system of faults on the deep seafloor.

*Earthquakes come in cycles; the modern cycle is not finished yet*

The megathrust earthquakes in 2004, 2005, and 2007 were larger than any other Sumatran earthquakes in the past century of seismometer recordings. Scientists at Earth Observatory of Singapore and LIPI (the Indonesian Institute of Sciences) look even further back in time by studying traces of ancient earthquakes as recorded in the growth patterns of corals on the chain of outer islands offshore of western Sumatra.

In Aceh, large earthquakes happened in 1394 and 1450. Evidence indicates that the 2004 earthquake released much, but not all, of the strain that had built up during the intervening centuries. There may be potential for another large earthquake and tsunami there sometime in the coming decades, mirroring the two-stage release of strain in 1394 and 1450.

Around the Mentawai Islands and the city of Padang in West Sumatra province, a series of large earthquakes has happened about every two centuries; the modern earthquake series began in 2007 and is likely to conclude with an earthquake as large as magnitude 8.8 and a large tsunami sometime in the coming decades.

Science cannot predict the day, month, or year of an earthquake, but can show us which areas face high earthquake and tsunami potential.

*Do earthquakes trigger one another?*

Earthquakes change the stress on neighbouring faults. In a span of just three years, the large Sumatran megathrust earthquakes of 2004, 2005, and 2007 have triggered one another in short order. Taken together, these earthquakes have effectively pulled on the oceanic Indian and Australian plates, perhaps triggering the 11-April 2012 earthquakes.

The data from the 11-April 2012 earthquakes provide important new clues that will help scientists unravel how the megathrust interacts with the strike-slip faults on the oceanic plates. It will also help us to better understand deep earthquakes within subducting plates, such as the destructive earthquake that struck Padang in September, 2009.

To probe deeply into these questions, EOS scientists have a unique tool: the 50 continuous GPS stations of the SuGAr network installed in Sumatra and the outer islands. They are busy unravelling the huge amount of data already accumulated on the many large Sumatran earthquakes in the past decade.

As the 11-April 2012 measurements start to flow in, preliminary data analysis indeed suggests interaction between the strike-slip faults on the deep seafloor and the megathrust: the 11-April earthquake has pushed back the leading edge of the Sunda/Eurasian plate about 20 cm north-eastward.

This research is critical for understanding earthquake and tsunami hazard. With this information, society can take many steps to reduce vulnerability to these hazards, from the individual and community to national and international levels.