

Study of tsunami and crustal movement caused by the 2004 Sumatra earthquake



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1. INTRODUCTION

The 2004 Sumatra earthquake (Mw 9.0 estimated by USGS) was caused by a rupture along the plate boundary where the Indian plate has been subducting under the Burma microplate in the NNE-SSW direction at the rate about 5 cm/yr (Fig.1). The after-shock distribution suggests that the rupture area extends in a long zone from west off-Sumatra to Andaman Islands for more than 1000 km. Tsunamis generated by this earthquake devastated the shores of Indonesia, Sri Lanka, South India, Thailand and Myanmar, and as far as the east coast of Africa. More than 200,000 people are thought to have died as a result of the tsunami.

For the scientific studies of source mechanism of this earthquake, crustal movement and physical size of tsunamis are the basic data. To document the tsunami disaster and measure the physical size, many scientists visited the coasts of Indian Ocean. Crustal movements of the Nicobar and Andaman Islands are crucial to determine the fault area and slip amount; however, the only northern part of the Andaman Island was surveyed by foreign researchers.

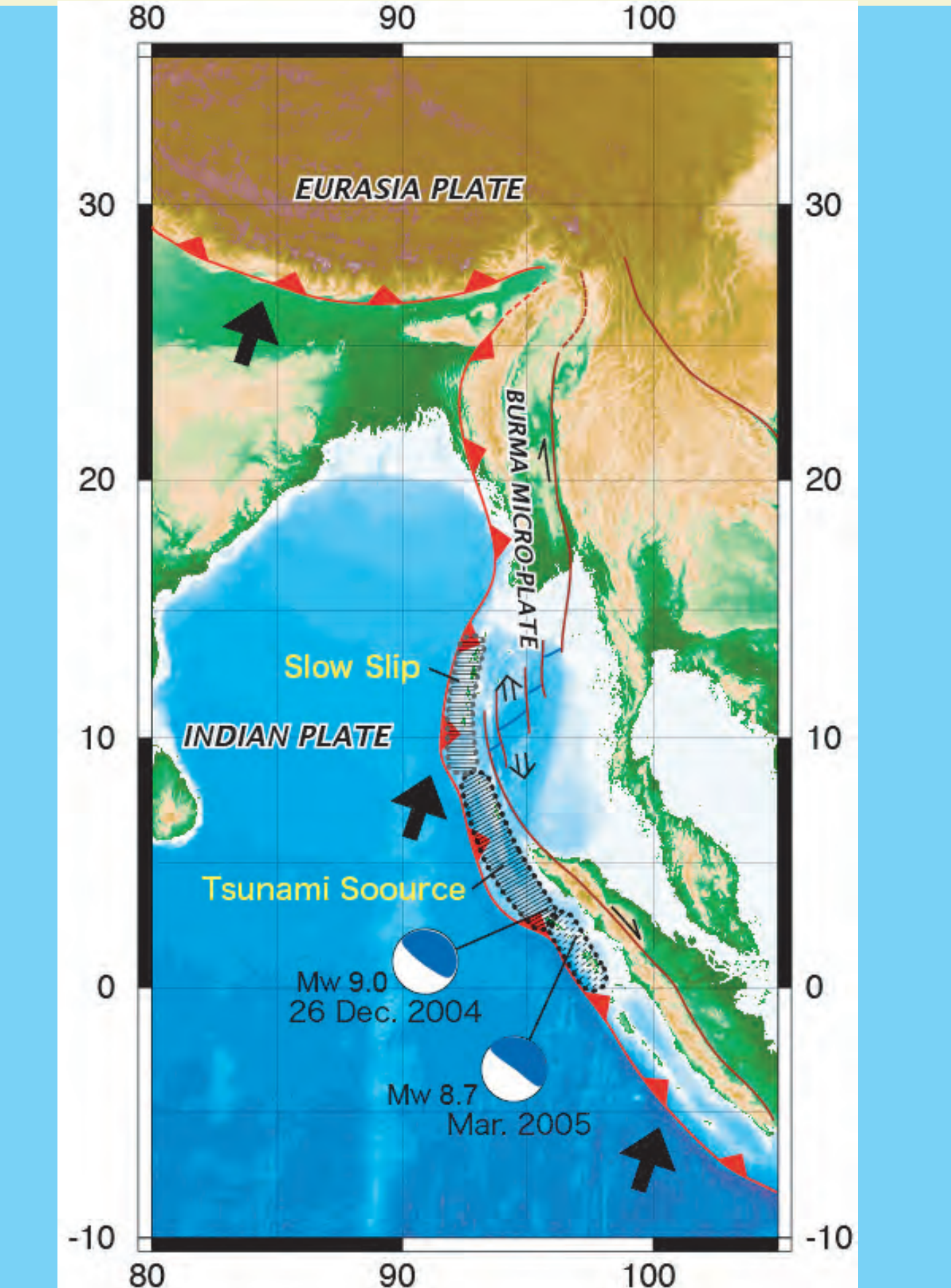


Figure 1 Location and tectonic map of the source area of the 2004 off-Sumatra earthquake

2. TSUNAMI SOURCE

The tsunami source area was estimated from tsunami waveforms and their arrival times recorded on tidal gages around the Indian Ocean. The source area extends from west off-Sumatra to Nicobar Island for about 700 km long (Fig.2). The tsunami simulation (Fig.3) based on the estimated source area nearly reproduces the arrival times and distribution of tsunami heights observed along the coastal areas of the Bengal Bay. The waves propagating in Indian Ocean were measured by a satellite altimeter (Fig.4), which agree well with the simulated waves.

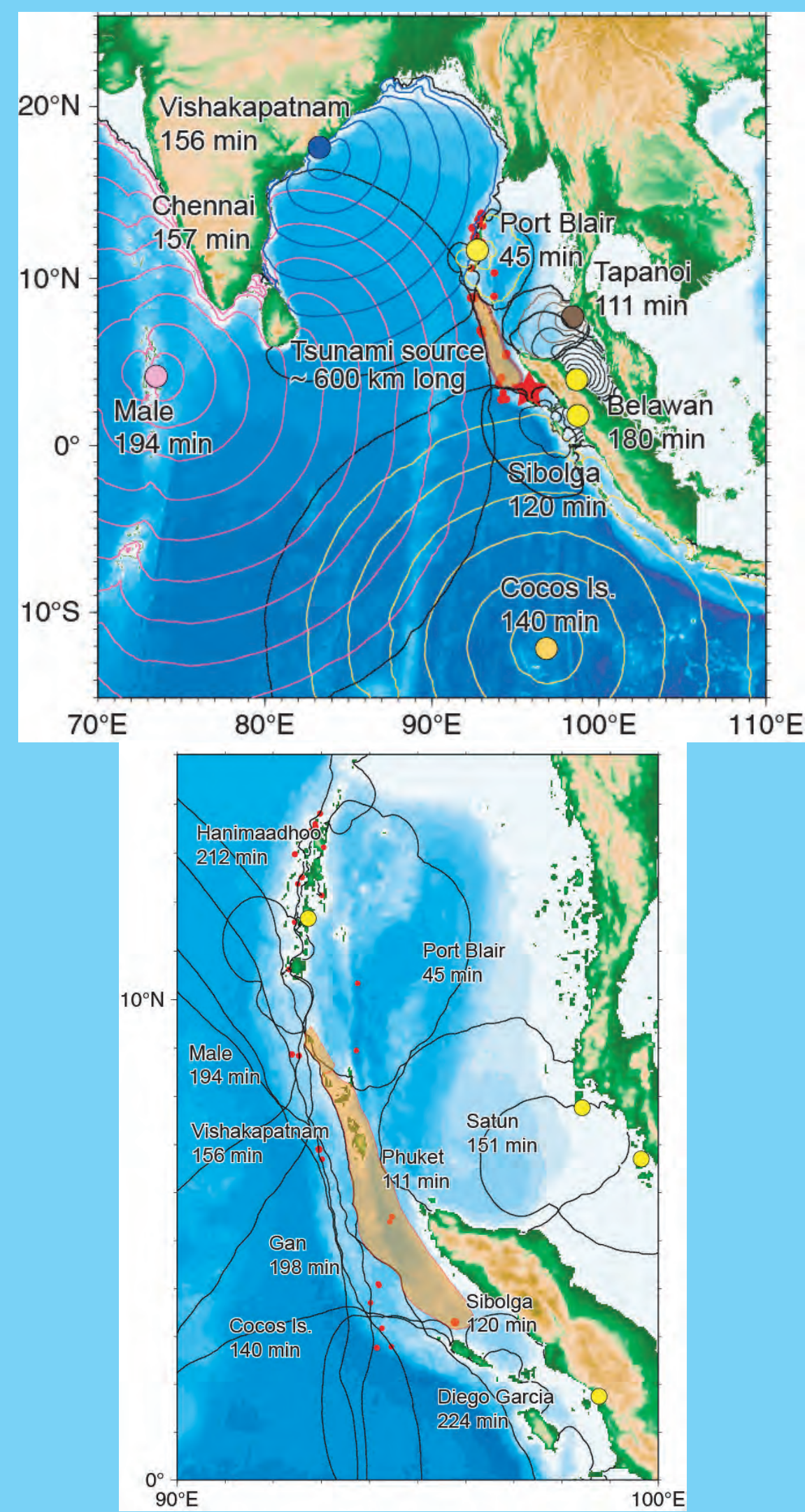


Figure 2 Source area of tsunami estimated by inverse propagation method

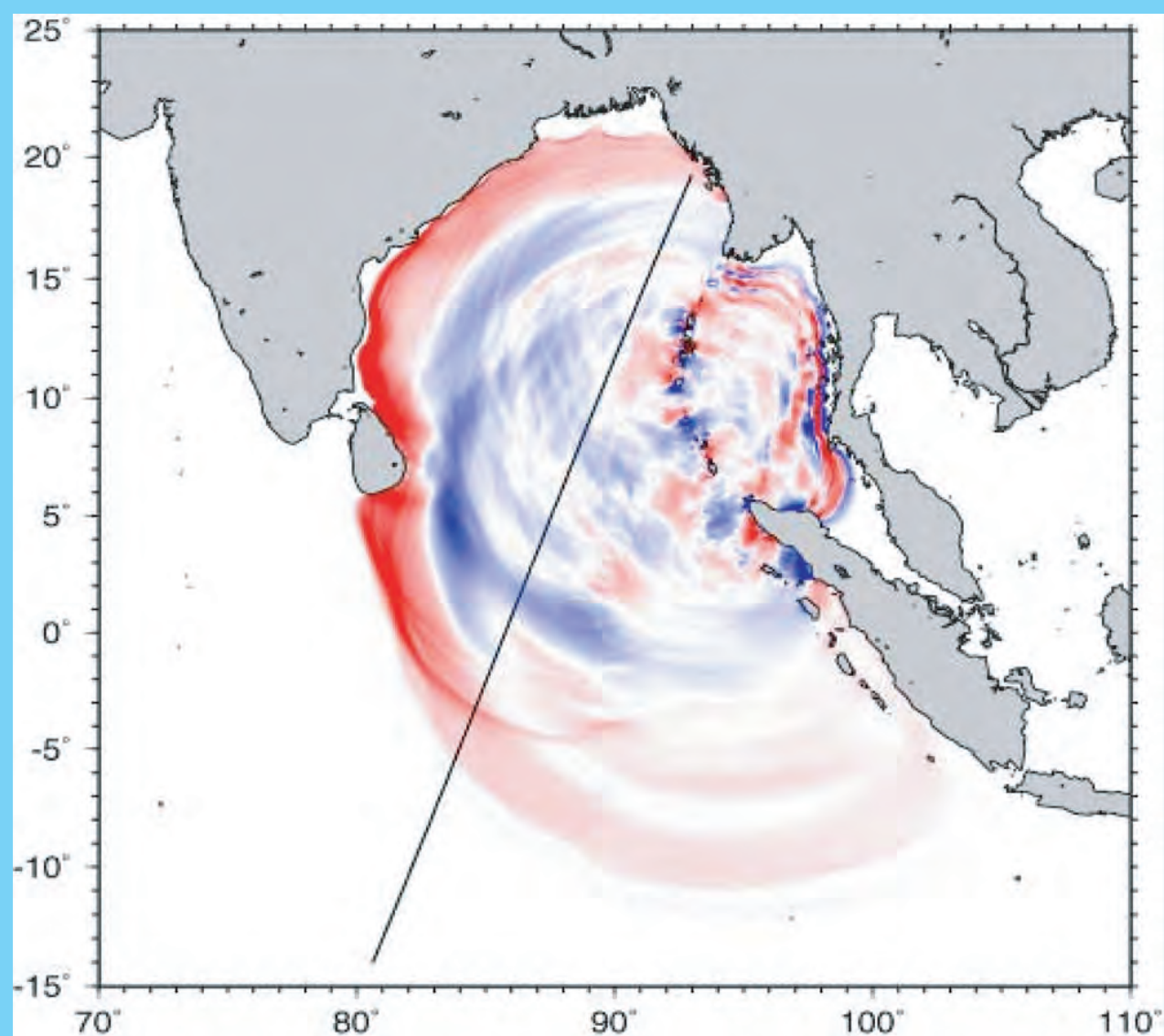


Figure 3 Example of tsunami simulation and satellite track (black solid line).

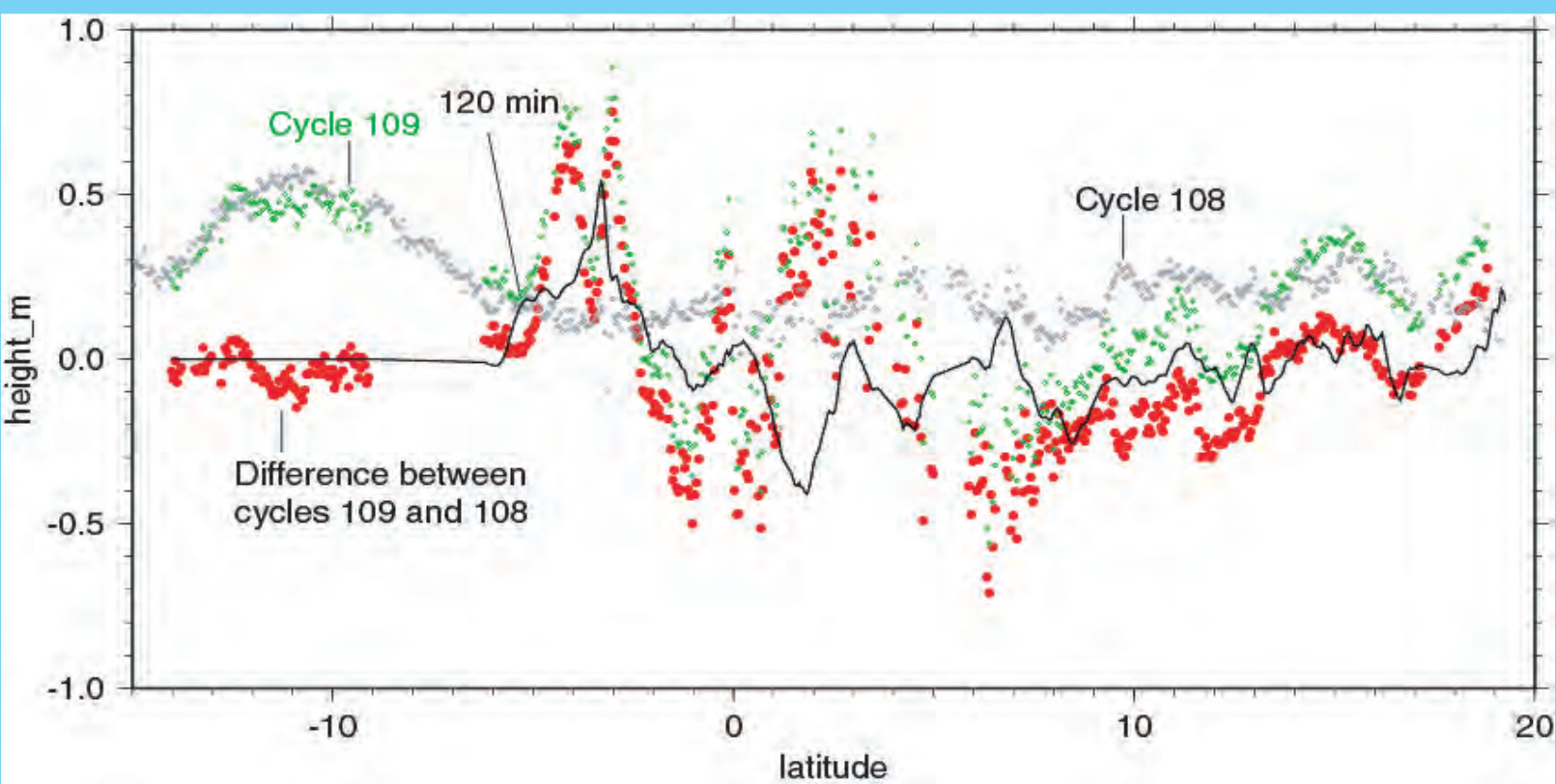


Figure 4 Tsunami records of satellite altimeter.

3. TSUNAMIS ALONG COASTAL AREAS

Tsunami heights and inundations were surveyed by interview to eyewitnesses and measurement of water marks of tsunami devastated areas (Fig.5). The western coast of northern Sumatra was attacked by tsunamis higher than 20 m and a part of Thailand and Sri Lanka were damaged by tsunami higher than 10 m. The tsunami heights on the coasts of Myanmar and Andaman Islands are smaller than 3 m and 5 m, respectively. These measurements indicate that higher tsunamis traveled to the east and west perpendicular to the strike of the source area.

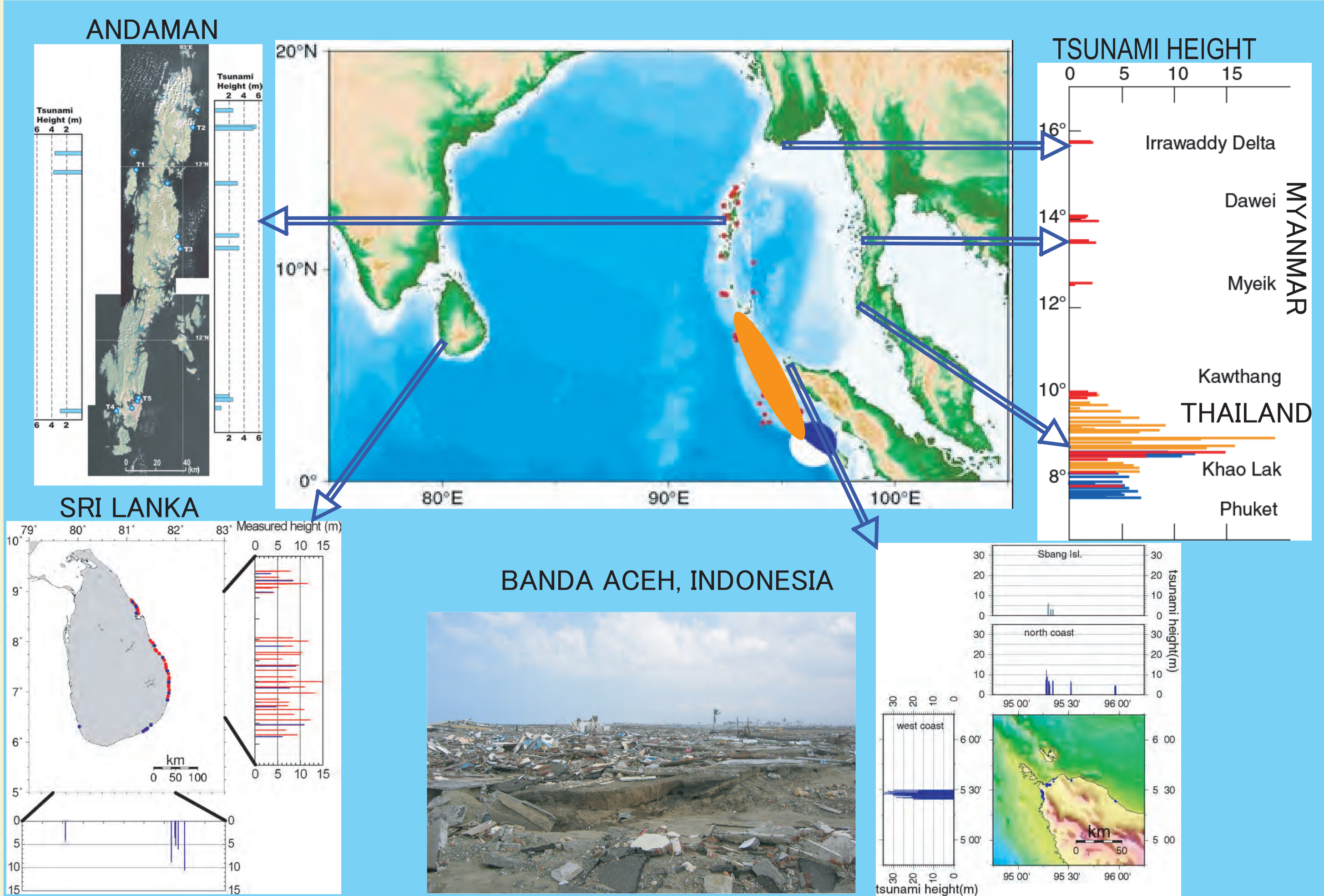


Figure 5 Tsunami heights measured along the coastal area of Bengal Bay

4. CRUSTAL MOVEMENTS

The fault slip caused crustal uplift and subsidence in the Andaman and Nicobar Islands. They were reported mainly by Indian scientists, and some parts of the Andaman Islands were surveyed by Japanese scientists as presented below (Fig.6). The results show that the fault slip extended to the farther north of the tsunami source area.

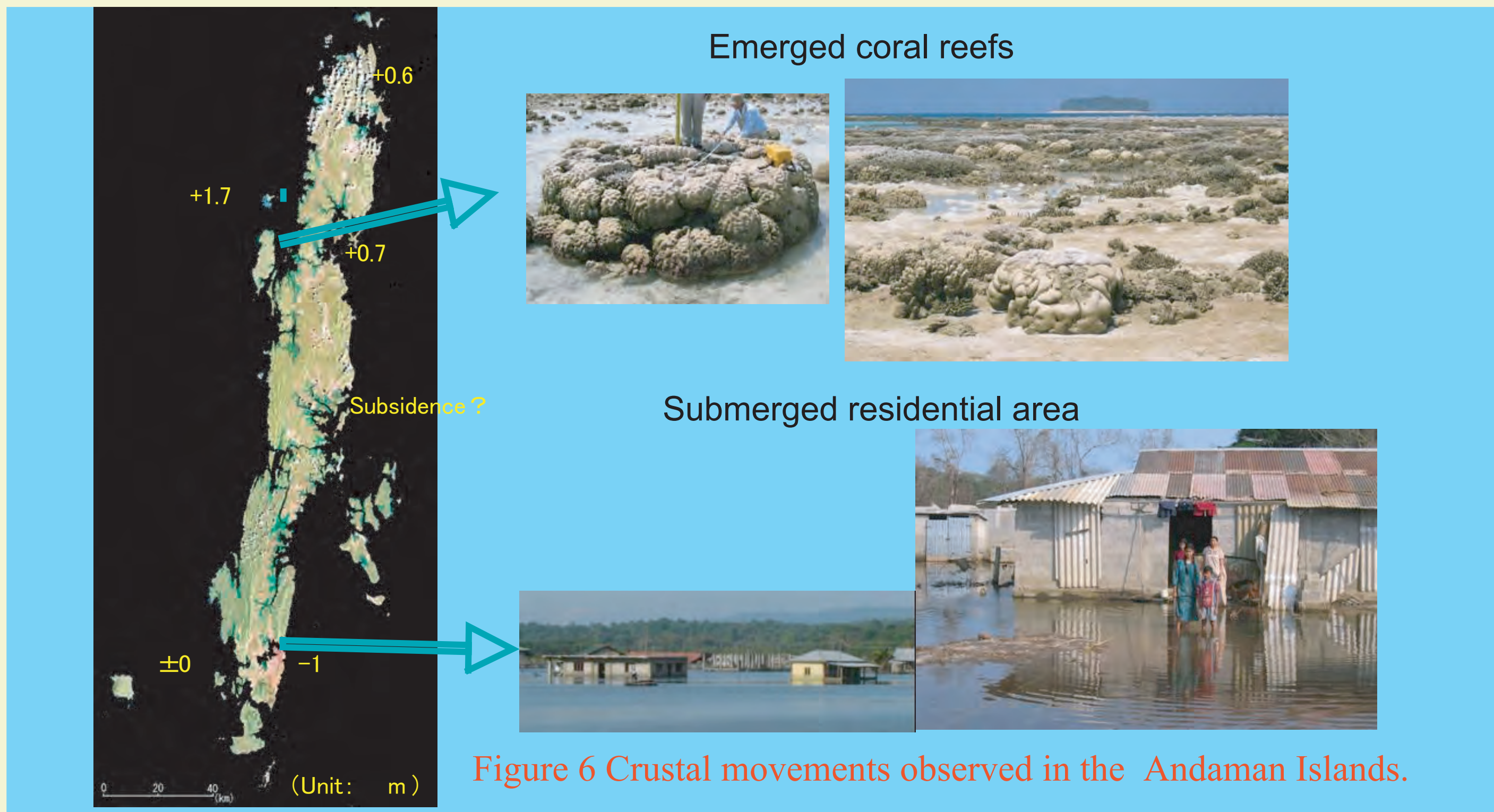


Figure 6 Crustal movements observed in the Andaman Islands.

5. CONCLUSIONS

1. The 2004 Sumatra earthquake occurred due to rupture along the subduction zone between Indian and Burma micro plates for more than 1000 km long.
2. Tsunamis propagated east and west were high and caused devastating disasters along the coast, whereas the tsunamis to the north were smaller and damages were less significant.
3. The Andaman Island is outside of the tsunami source area within the area of co-seismic crustal movements.
4. These observations indicate that the tsunami source area was about 700 km long from west off-Sumatra to the Nicobar Islands, but slow slip extended farther north to the Andaman Islands.