

# M9.1 Sumatra - Andaman Islands Earthquake of 26 December 2004

Prepared in cooperation with the Global Seismographic Network



## Tectonic Setting



## Generalized Seismic Hazard

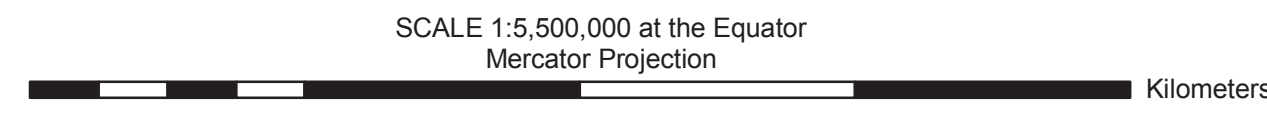
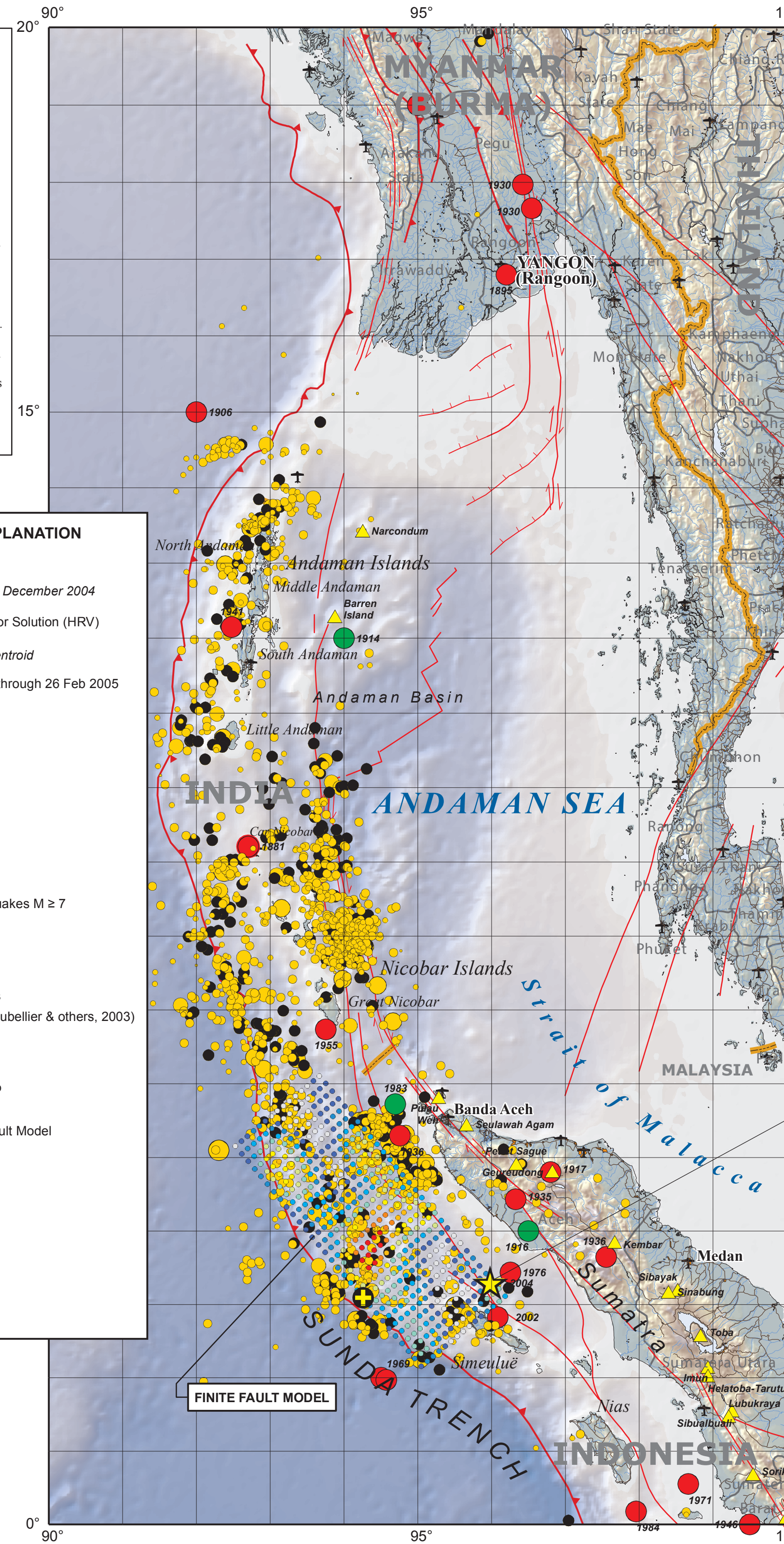
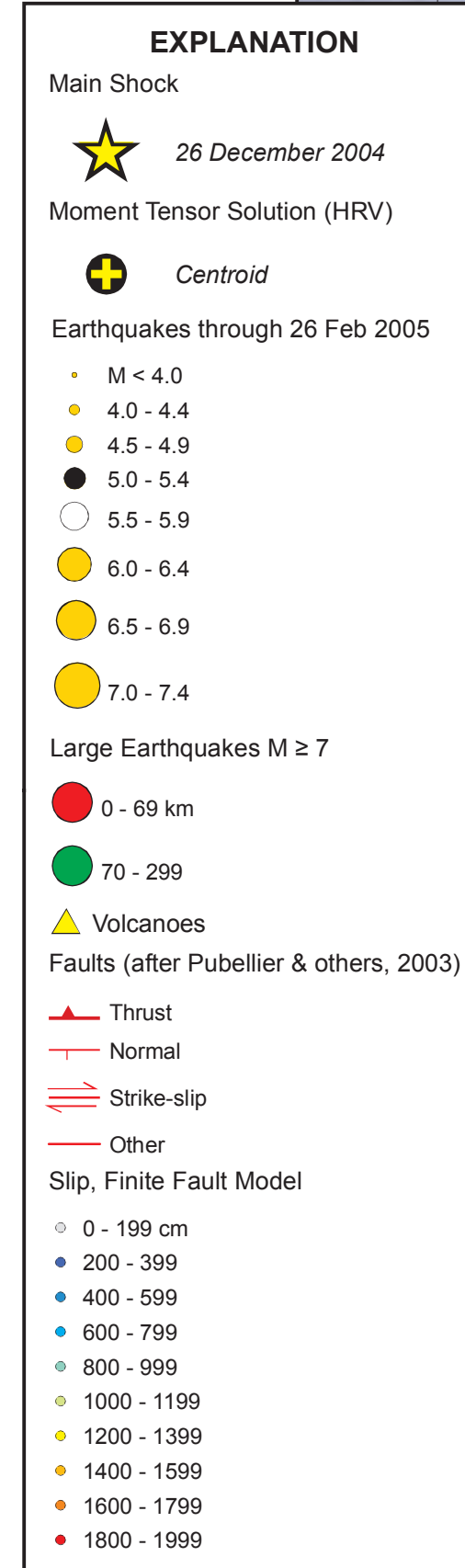
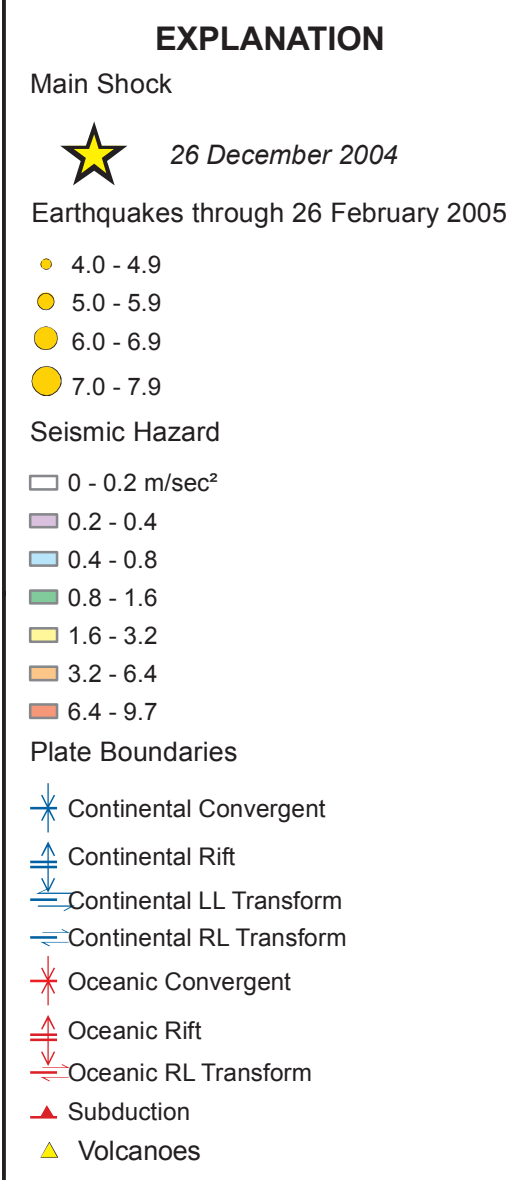


RELATIVE PLATE MOTIONS

The broad red vectors represent the motion of the India and Australia plates with respect to the interior of the Eurasia plate. The motion of India and Australia generally northward with respect to Eurasia produces motion of many smaller plates that lie between the India/Australia plates and the Eurasia plate. The 26 December earthquake occurred on the boundary between one of the smaller plates, the Burma microplate, and the India plate.

Faults and plate-boundaries in this map are represented at two levels of precision. Within the rectangle labeled "Detailed Map," faults are represented as mapped in regional geologic and oceanographic studies (Pubellier and others, 2003). These faults are also shown in the detailed map in the center of this poster. Outside the "Detailed Map" rectangle, plate boundaries are represented very generally. Some of the mapped boundaries correspond to narrow fault zones, but others of the mapped boundaries are line approximations to what are in fact broad areas of distributed deformation, and yet others correspond to boundaries between regions having different levels of deformation.

The Burma microplate is the 200 km - 400 km region that is bounded on the west by the thrust-fault system that outcrops at the Sunda trench and on the east by a zone of strike-slip faults and normal faults that passes east of the Andaman Islands and Nicobar Islands. The Burma microplate is taken to extend south from a zone of deformation in southern Burma, through the Andaman and Nicobar Islands, to northern Sumatra.



## DISCUSSION

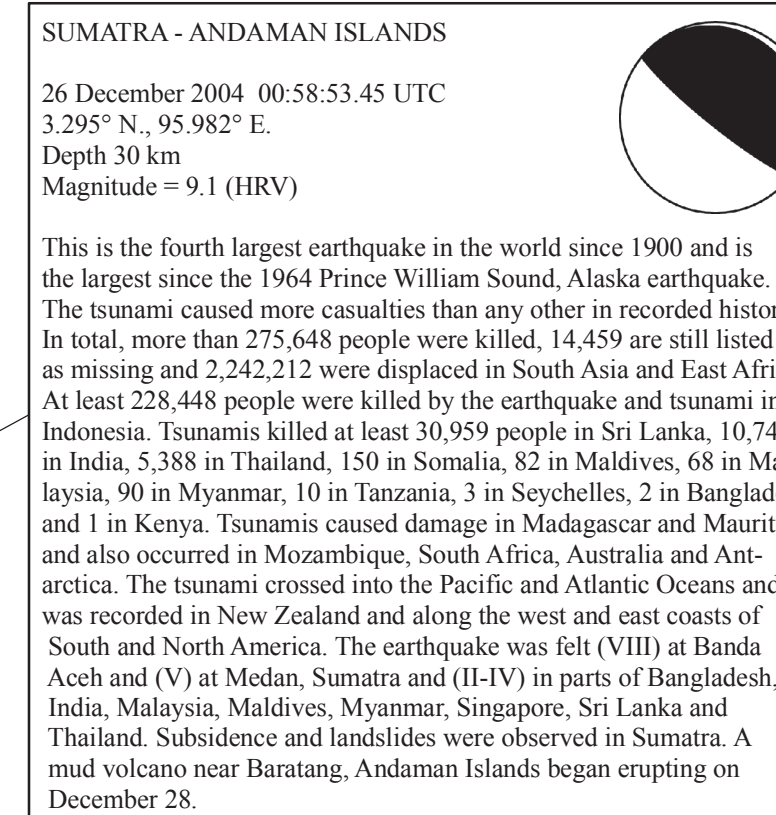
The devastating earthquake of 26 December 2004 occurred as thrust-faulting on the interface of the India plate and the Burma microplate. In a period of minutes, the faulting released elastic strains that had accumulated for centuries from ongoing subduction of the India plate beneath the overriding Burma microplate.

In a broad sense, the India and Australian plates move toward the north-northeast with respect to the interior of the Eurasia plate with velocities of about 60 mm/yr in the region of the earthquake. This results in oblique convergence at the Sunda trench. The oblique motion is partitioned into thrust-faulting, which occurs on the interface between the India plate and the Burma microplate and involves slip directed at a large angle to the orientation of the trench, and strike-slip faulting, which occurs on the eastern boundary of the Burma microplate and involves slip directed approximately parallel to the trench. Details of the velocity of the Burma microplate remain to be determined and may, in fact, be clarified by further analysis of the December main shock and its aftershocks.

Currently available models of the 26 December main-shock fault displacement differ in many interesting details, but are consistent in implying that fault-rupture propagated to the northwest from the epicenter and that substantial fault-rupture occurred hundreds of kilometers northwest of the epicenter. The data upon which the modeling is based do not permit confident resolution of the extent of rupture beyond about 500 km northwest of the main-shock epicenter. The finite fault model shown here implies that the width of the earthquake rupture, measured perpendicular to the trench, was about 150 kilometers, and that the maximum displacement on the fault plane was about 20 meters. The sea floor overlying the thrust fault would have been uplifted by several meters as a result of the earthquake.

The zone of aftershocks to the 26 December earthquake is over 1300 km long. Because aftershocks occur on and very near the fault-planes of main shocks, the length of the aftershock zone suggests that main-shock fault-rupture may have extended north of epicenter by an amount significantly larger than 500 km. However, a great earthquake may also trigger earthquake activity on faults that are distinct from the main-shock fault plane and separated from it by tens or even hundreds of kilometers. We will not know until further analysis how much of the 26 December aftershock zone may correspond to activity in the immediate vicinity of the main-shock rupture, and how much may correspond to activity remote from the main-shock rupture.

Since 1900, earthquakes similarly sized or larger than the 26 December earthquake have been the magnitude 9.1 1957 Andreanof Islands, Alaska, earthquake, the magnitude 9.5 1960 Chile earthquake, and the magnitude 9.2 1964 Prince William Sound, Alaska, earthquake. All of these earthquakes, like the 26 December earthquake, were mega-thrust events, occurring where one tectonic plate subducts beneath another. All produced destructive tsunamis, although deaths and damage from the 26 December tsunami have far exceeded those caused by tsunamis associated with the earlier earthquakes.



## DATA SOURCES

**EARTHQUAKES AND SEISMIC HAZARD**

USGS, National Earthquake Information Center

NOAA, National Geophysical Data Center

IASI/IGC, Centennial Catalog (1900 - 1999) and extensions (Engdahl and Villaseñor, 2002)

HDF (unpublished earthquake catalog) (Engdahl, 2003)

Global Seismic Hazard Assessment Program

**PLATE TECTONICS AND FAULTS**

1900 - 1999, chap. 41 of Lee, W.H.K., and others, eds., International Earthquake and Engineering Seismology, Part A: New York, N.Y., Elsevier Academic Press, 932 p.

Engdahl, E.R., Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: Bull. Seism. Soc. Amer., v. 88, p. 722-743.

Ortiz, M. and Bilham, R., 2003, Source area and rupture parameters of the 31 December 1881 Mw = 7.9 Car Nicobar earthquake estimated from tsunamis recorded in the Bay of Bengal: Jour. Geophys. Res., v. 108, p. 2215-2231.

Pubellier, M., Ego, F., Chamot-Rooke, N., and Rangin, C., 2003, The building of pericratonic mountain ranges: structural and kinematic constraints applied to GIS-based reconstructions of SE Asia: Bull. Soc. Geol. France, v. 174, p. 561-584.

**VOLCANOES**

Smithsonian Institution, Global Volcano Program

**BASE MAP**

NIMA and ESRI, Digital Chart of the World

USGS, EROS Data Center

**OTHER SOURCES**

Associated Press

UN Office for Coordination of Humanitarian Affairs (OCHA)

Zachariasen, J. and others, 1999, Submergence and uplift associated with the giant 1833 Sumatran subduction zone earthquake: Evidence from coral microatolls: J. Geophys. Res., v. 104, p. 895-919.

## REFERENCES

Bird, P., 2003, An updated digital model of plate boundaries: Geochim. Geophys. Geosyst., v. 4, no. 3, pp. 1027-80.

Engdahl, E.R. and Villaseñor, A., 2002, Global Seismicity: 1900 - 1999, chap. 41 of Lee, W.H.K., and others, eds., International Earthquake and Engineering Seismology, Part A: New York, N.Y., Elsevier Academic Press, 932 p.

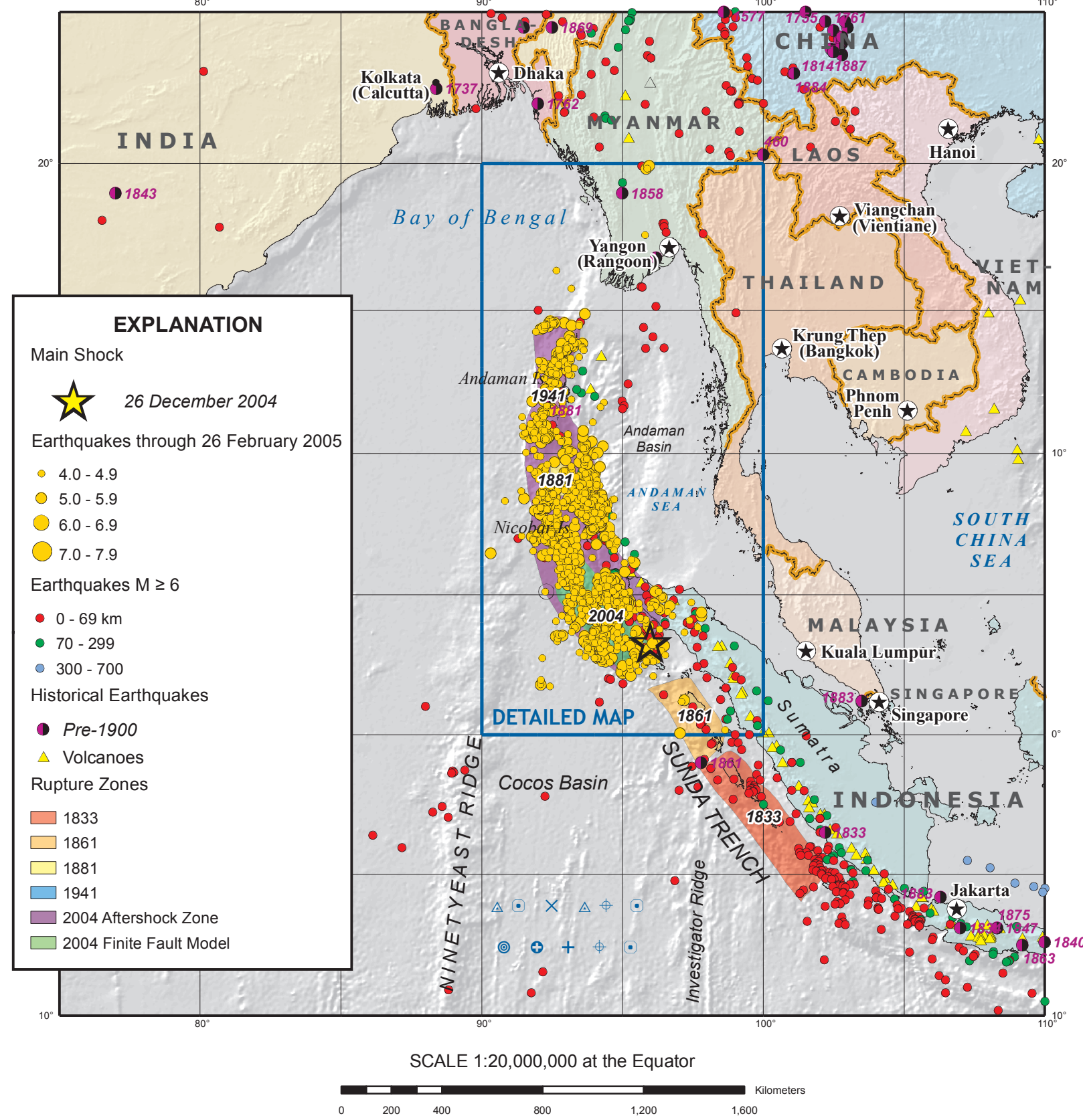
Engdahl, E.R., Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: Bull. Seism. Soc. Amer., v. 88, p. 722-743.

Ortiz, M. and Bilham, R., 2003, Source area and rupture parameters of the 31 December 1881 Mw = 7.9 Car Nicobar earthquake estimated from tsunamis recorded in the Bay of Bengal: Jour. Geophys. Res., v. 108, p. 2215-2231.

Pubellier, M., Ego, F., Chamot-Rooke, N., and Rangin, C., 2003, The building of pericratonic mountain ranges: structural and kinematic constraints applied to GIS-based reconstructions of SE Asia: Bull. Soc. Geol. France, v. 174, p. 561-584.

Zachariasen, J. and others, 1999, Submergence and uplift associated with the giant 1833 Sumatran subduction zone earthquake: Evidence from coral microatolls: J. Geophys. Res., v. 104, p. 895-919.

## Seismicity of the Northeast Indian Ocean 1900 - 2004



## Finite Fault Model

